TOPPS Water Protection

Best Management Practice -
to reduce spray drift

Information & Training Course

Content

PPP – entry routes and perceptions

Definition of spray drift

Drift curves

Key factors influencing drift

Factors out of our direct control

How to reduce spray losses from drift ?

- Droplet size
- Droplet generation
- Nozzles / selection
- Distance to target
- Boom height
- Shielded spraying
- Driving speed

Additional complexity in

Orchard, Vine and Bush crops

- Sprayer adjustment

Indirect spray drift risk reduction measures

Challenges in the EU to develop consistent and harmonized approach

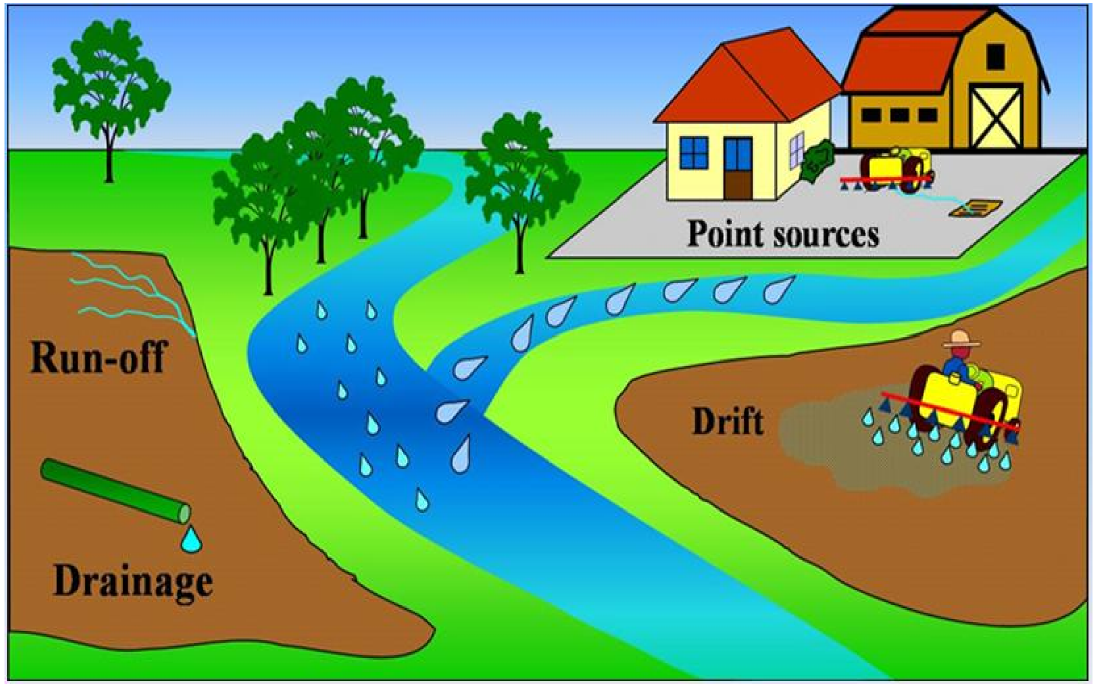
Conclusions

Compiled by Univ Turin Deiafa
Manfred Roettele TOPPS - PM

Main entry routes of PPP to surface water

Point sources
Handling on farm
(filling, cleaning,
remnant management)

Diffuse sources
Field run off
Drainage
Spray drift

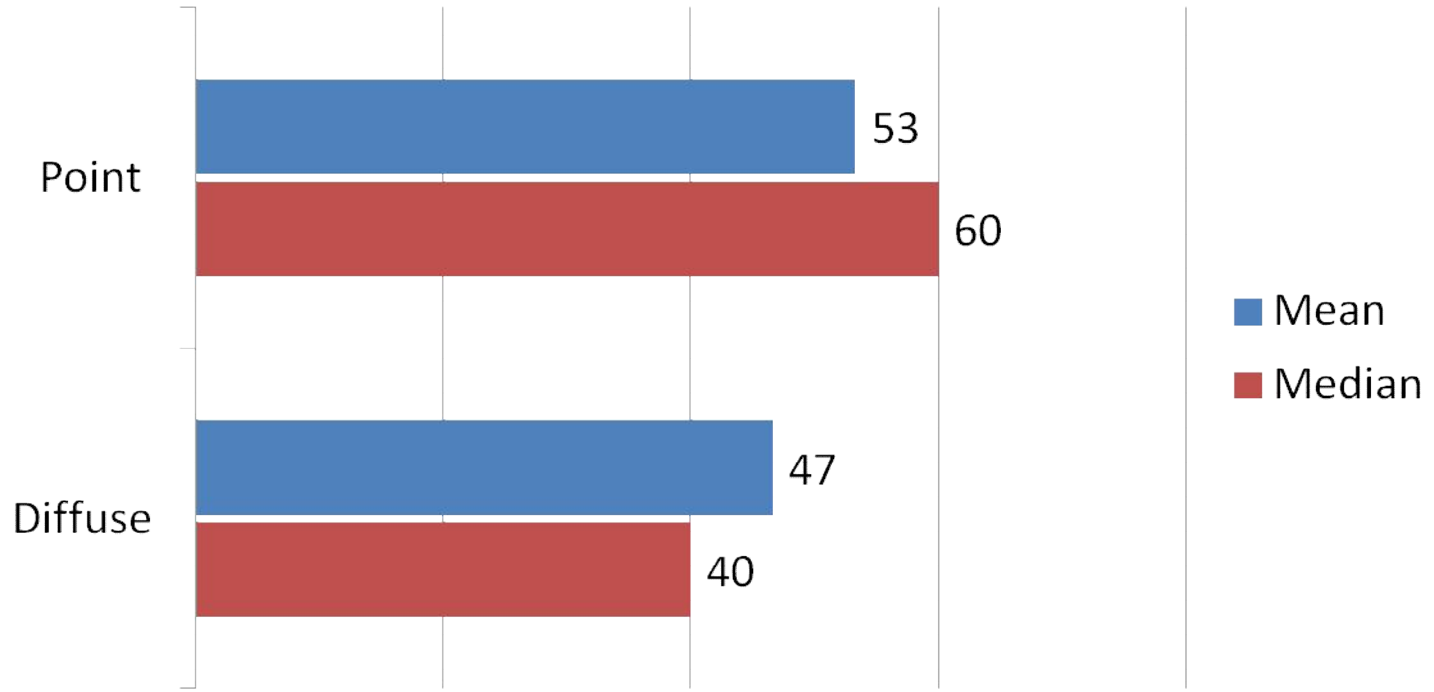


Spray drift is quantitatively the least important entry route to water, but the most visible

SIGNIFICANCE OF ENTRY ROUTES

Stakeholder survey 2011/2012 in 7 countries

If you consider the two main entry routes of PPP - point and diffuse sources into surface water how would you estimate their significance in % ?



Point sources are perceived the main entry route
BUT VARIATIONS BETWEEN RESPONDENTS ARE BIG

Stakeholder survey (n=680; ES, IT, FR, DE, BE, DK, PL)

SIGNIFICANCE OF DIFFUSE SOURCES

Stakeholder survey 2011/2012 in 7 countries

Please rank the different diffuse entry routes in order of their importance (1= most important … 4 least important)

Average ranks on the significance of diffuse sources								
Country	BE	DE	DK	ES	FR	IT	PL	all
Runoff	2,06	**1,99**	**2,23**	**2,04**	**1,45**	**1,93**	**1,96**	**1,97**
Spraydrift	**2,36**	**2,82**	**1,98**	**2,23**	**2,36**	**2,38**	**2,39**	**2,41**
Drainage	**2,73**	**2,68**	**2,63**	**2,38**	**3,02**	**2,31**	**2,28**	**2,58**
Erosion	**2,82**	**2,51**	**3,17**	**3,36**	**3,16**	**3,38**	**3,37**	**3,04**
n	**71**	**92**	**48**	**56**	**44**	**55**	**46**	**412**

Runoff is generally perceived as the number one diffuse entry route, except in DK. Spraydrift is considered on average the second most important diffuse source, but not in DE, IT and PL

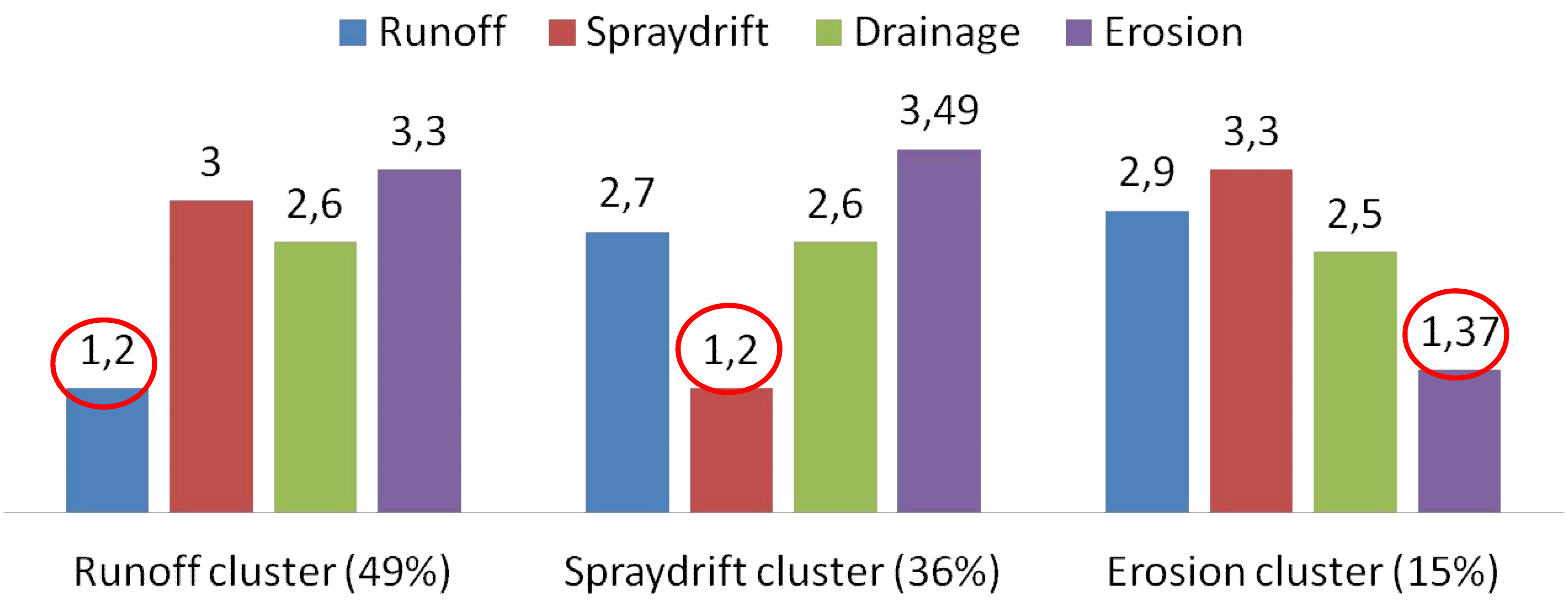
Attention: Lowest number more important (ranking methode)

PERCEPTION ON SIGNIFICANCE DIFFER WIDELY

Stakeholder survey 2011/2012 in 7 countries

Cluster analysis separates three different groups of respondents in their evaluation of main diffuse sources

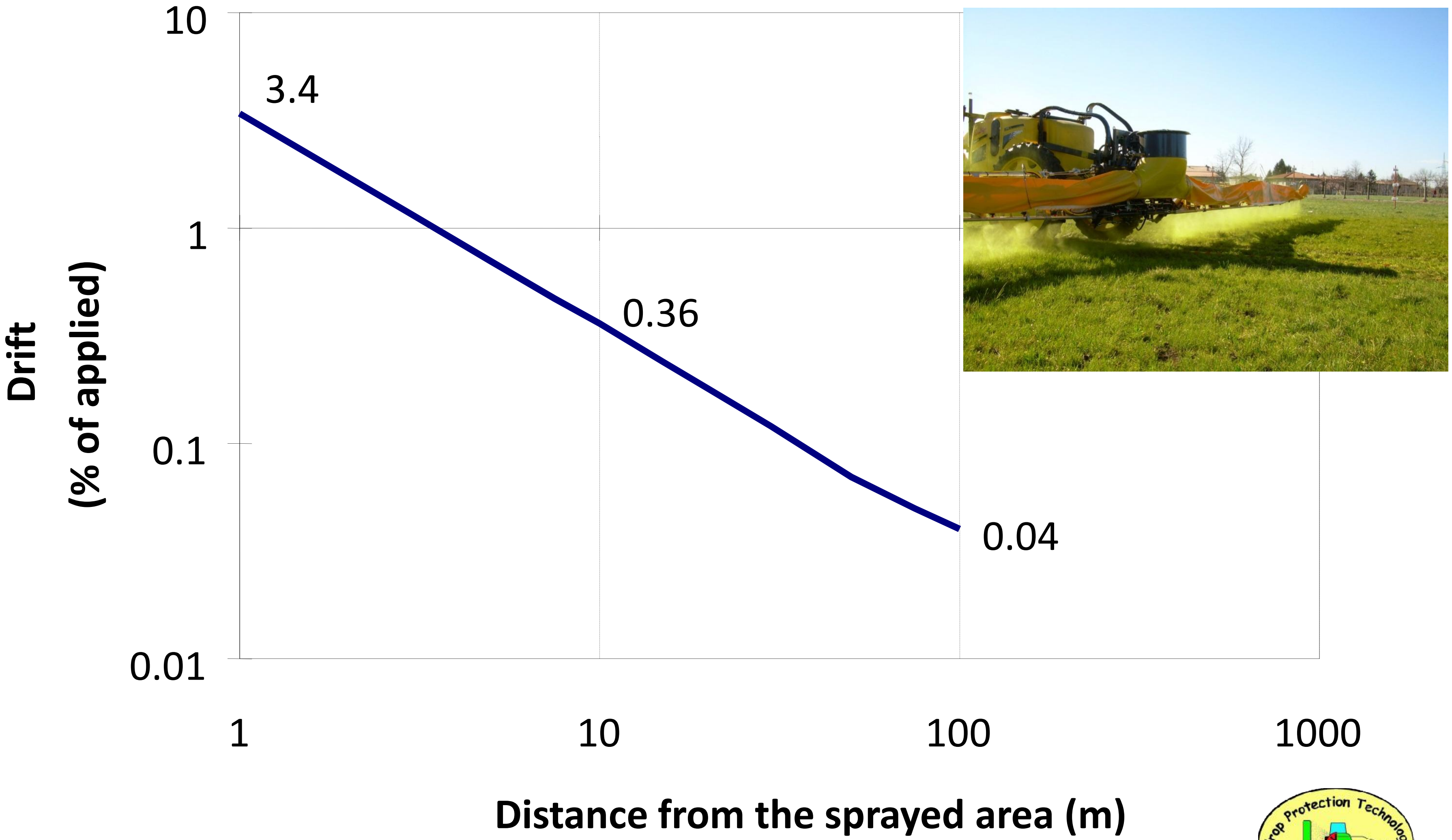
Average ranks in clusters (1 most important …. 5 least important)



SPRAY DRIFT:“*Quantity of plant protection product (PPP) that is carried out of the sprayed (treated) area by the action of air currents during the application process*” (ISO 22866)

AMOUNT OF DRIFT IN FIELD CROPS

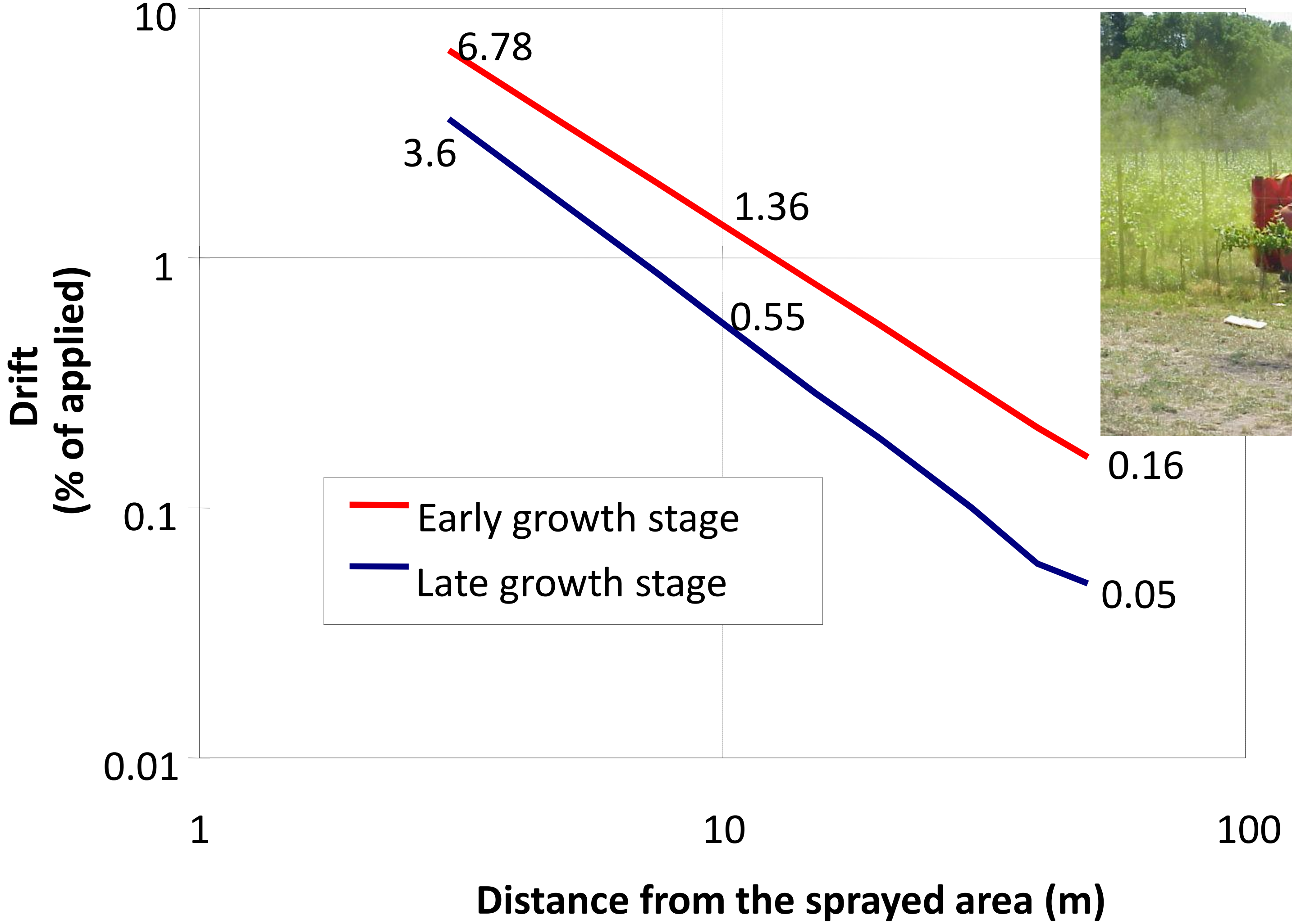
Drift curves – basis for risk assessments



(from Ganzelmeier et al. 2000)

AMOUNT OF DRIFT IN VINEYARD

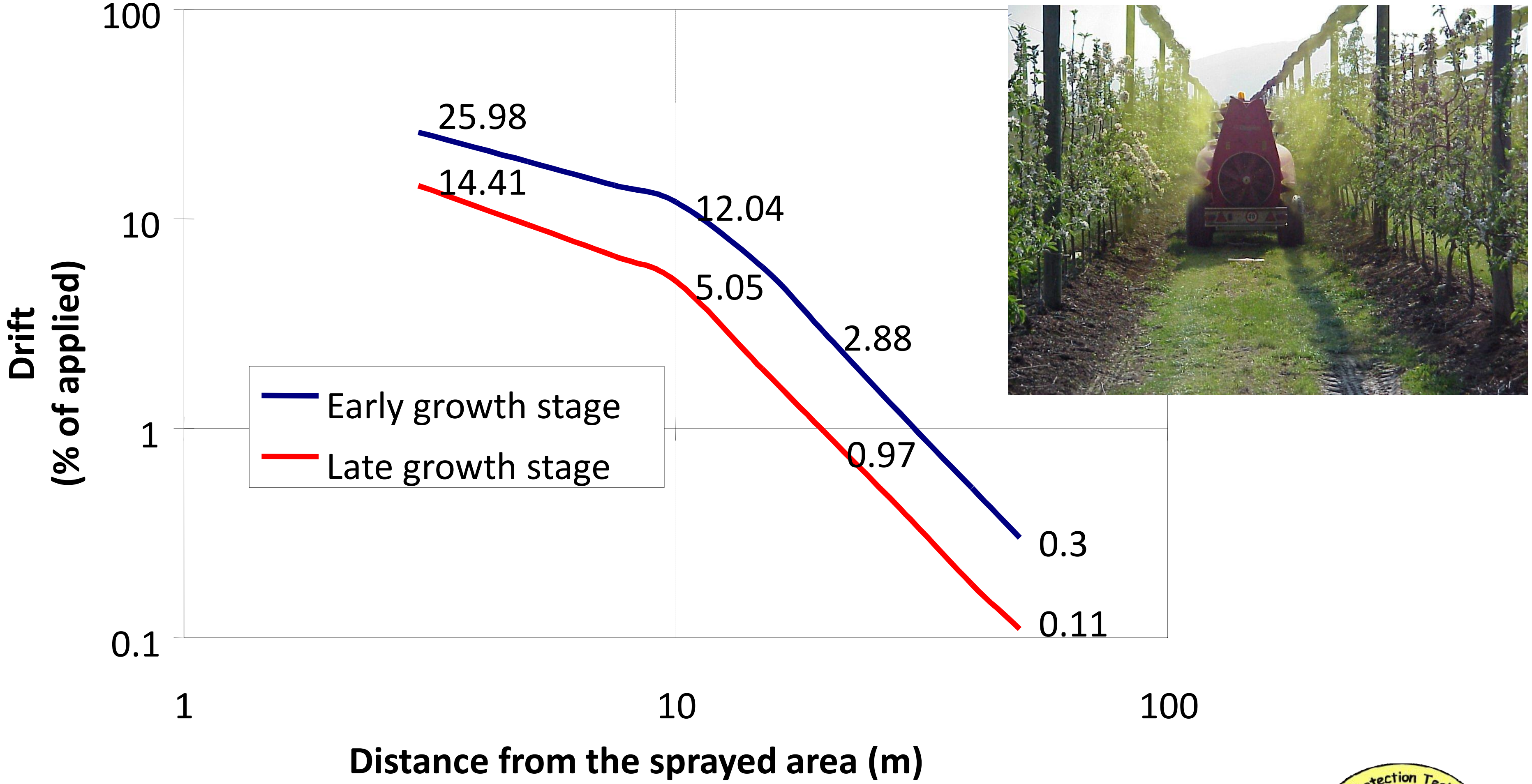
Drift curves – basis for risk assessments



(from Ganzelmeier et al. 2000)

AMOUNT OF DRIFT IN ORCHARD

Drift curves – basis for risk assessments



(from Ganzelmeier et al. 2000)

Drift measurement approaches vary between countries in EU (South and East at the beginning)

(Report*: Joined spray drift curves for boom sprayers in The Netherlands and Germany)

Table 1. Summary table reference boom sprayer.

Item/country	NL	DE	UK	FR	PL	BE	SE
Nozzle	XR11004	FF 03, 04*)	FF110/1.2/3.0	FF11002	FF03	FF03	F, M. C
Spray pressure (bar)	3	2.0 – 5.0	3	2.5	-	3	-
Spray volume (l/ha)	300	150 - 300	Speed dependent	-	-	-	-
Sprayer speed (km/h)	6.5	6-8	6-12 [12,16]†	8	-	-	7.2
Boom height (m)	0.50	0.50	0.5 [0.7, 1.0]†	0.70	0.50	0.50	0.25, 0.40, 0.60
Sprayed surface	Potato, bare soil	Bare soil, Short grass	Short grass – crop	-	-	-	Short grass
Crop height (m)	0.50 / 0.10	0.10	0.05-2.0	-	-	-	-
Sprayed width (m)	24	20	48	-	-	-	96
Temperature range (°C)	5-25	10-25	-	-	-	-	10, 15, 20
Wind speed range (m/s)	1.5-5.0	1-5	2.5 [2.5, 3.5]†	-	-	-	3.0, 4.5
Wind speed height (m)	2.0	2.0	3	-	-	-	2.0

*) *Basic drift curve contains data from measurements with other flat fan (FF) nozzle types and sizes (coarser sprays – lower drift).*

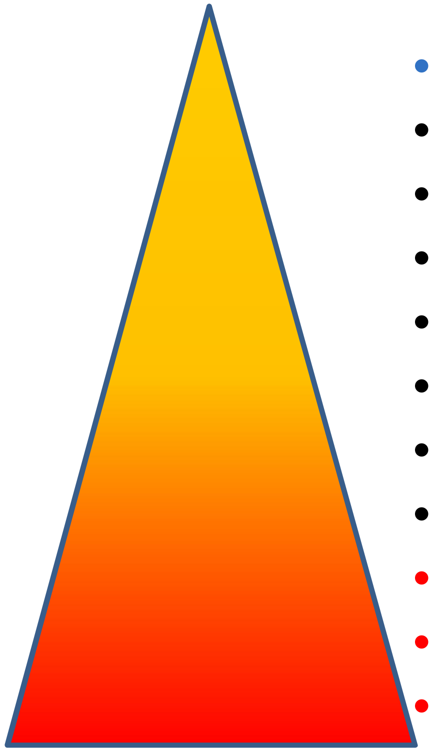
† *Values in square brackets are recently proposed (not yet adopted) for bystander/resident assessments.*

* J.C. van de Zande, D. Rautmann, H.J. Holterman & J.F.M. Huijsmans.- Plant Research International, part of Wageningen UR Report 526

Factors influenceing spray drift

Factors we can influence and some are out of direct control

indirect influence



direct influence

Key factors

- **Wind speed**
- **Wind direction**
- **Temparature**
- **Air humidity**
- Proximity to water
- Proximity sensitive area
- **Crop treated**
- **Adjacent area**
- **Droplet size**
- **Application technique**
- **Adjustment of sprayers**

Factors out of direct control

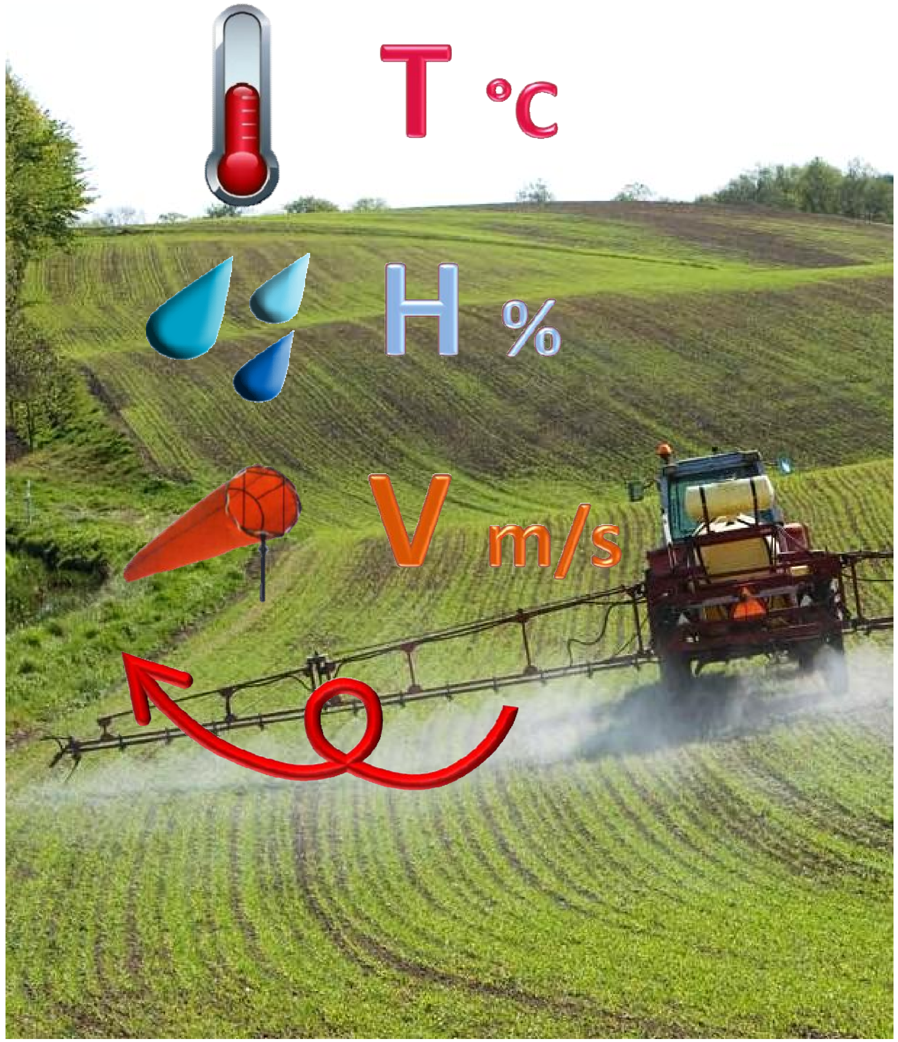
weather conditions – proximity to sensitive areas

High temperatures can cause thermic drift (do not spray above 25 degrees) (spray in morning / evening)

Under low air humidity small droplets can evaporate
(do not spray at air humidity < 40%)

Windspeed and wind direction determine largly how much spray quantity will be lost (do not spray at wind speeds > 5m/s

Proximity to water / sensitive area require careful planning of the application and application times (spray in morning / evening)



Crops have a strong influence on the spray drift risk

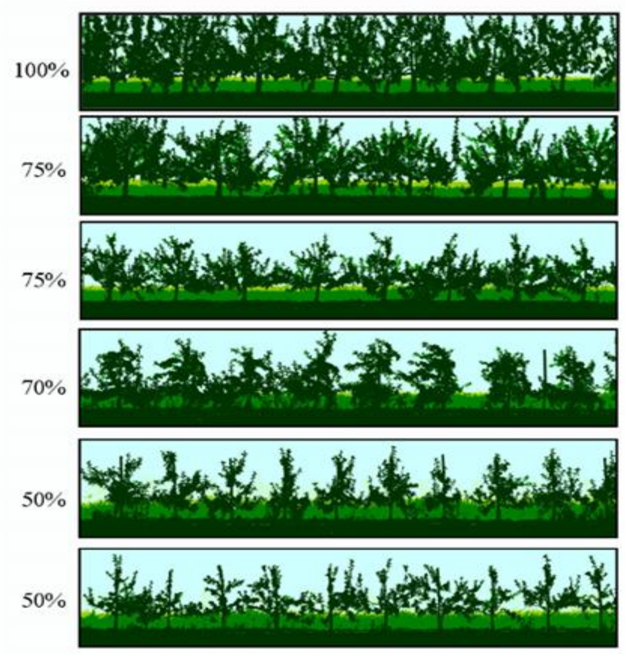
Arable crops

- drift risk on bare soil is higher than on established vegetation

- with higher vegetation the drift risk increases

Orchard / vine crops

- drift risk is high early in season due to less developed leaf area
- drift risk decreases with full density of the „leaf – wall“



Adjacent area / vegetation influence the spray drift risk

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HOW TO REDUCE SPRAY LOSSES DUE TO DRIFT?

Crop Protection Technology – DEIAFA - Meccanica – Università di Torino

MEASURES TO PROTECT ENVIRONMENT FROM DRIFT

DIRECT

Reducing drift at source

Use of Spray Drift Reduction Technology (SDRT)

- **Application equipment**
- **Adjustment of sprayers**
- **Application parameters**
- **Application scenario**

INDIRECT

Reducing exposure to drift

No spray zones
Buffer zones

Natural vegetative strips
Windbreaks, hail nets, etc.

- **Fixed buffer zones**
- **Adjustable buffer zones (depending on spray application technology)**

Regulatory activities

Key parameters to reduce the spray drift risk

Field applications

- Droplet size
- Distance to target
- Forward speed

Orchard applications

- Droplet size
- Distance to target
- Air volume
- Air speed
- Air direction

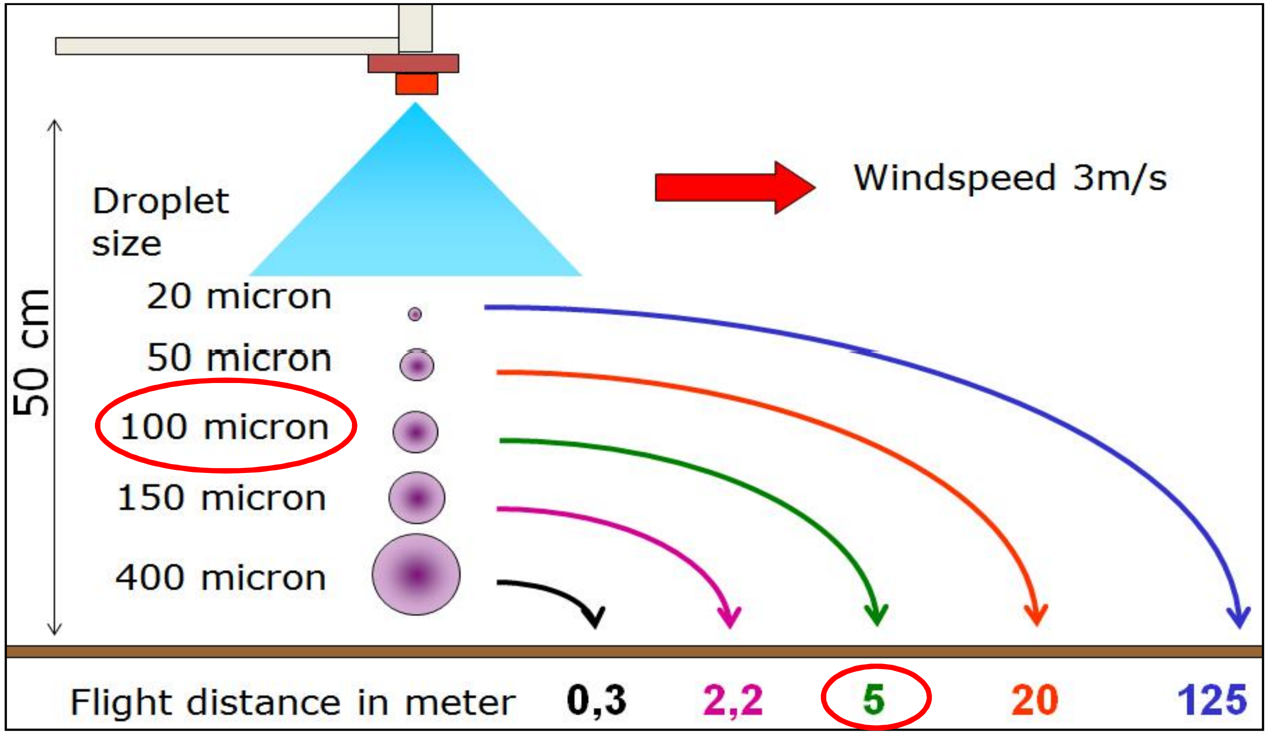
Most important is the correct adjustment of the sprayer

Consider droplet size!!!

BCPC Specification	Droplet size	MVD -Mean Volume Diameter	Coverage	Penetration canopy	Drift risk
Very fine VF		125 µm= 0,12 mm			
Fine F		250 µm= 0,25 mm			
Medium M		350 µm= 0,35 mm			
Coarse C		450 µm= 0,45 mm			
Very coarse VC		575 µm= 0,57 mm			

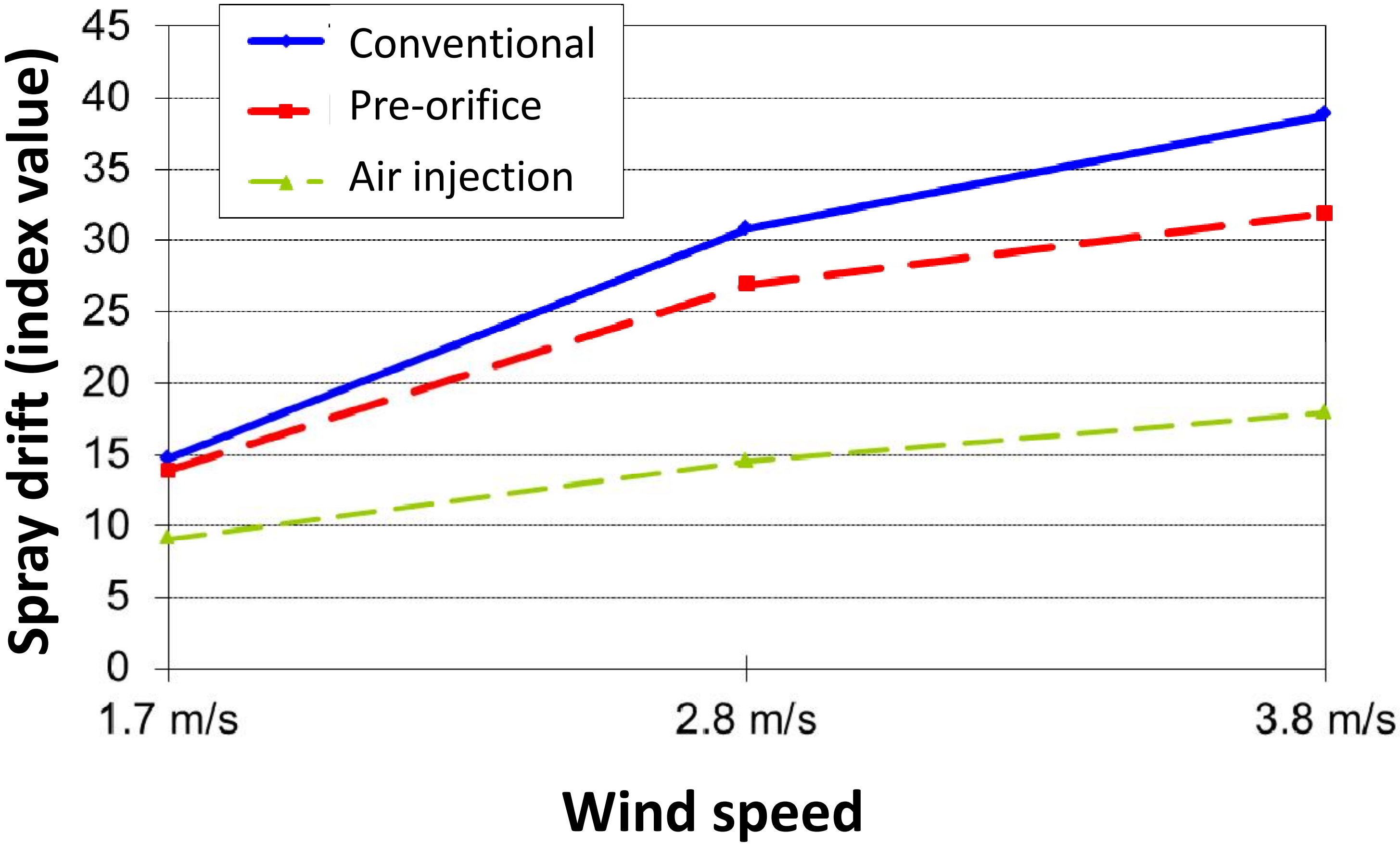
DROPLET SIZE:

Small droplets are more sensitive to wind and increase the drift risk



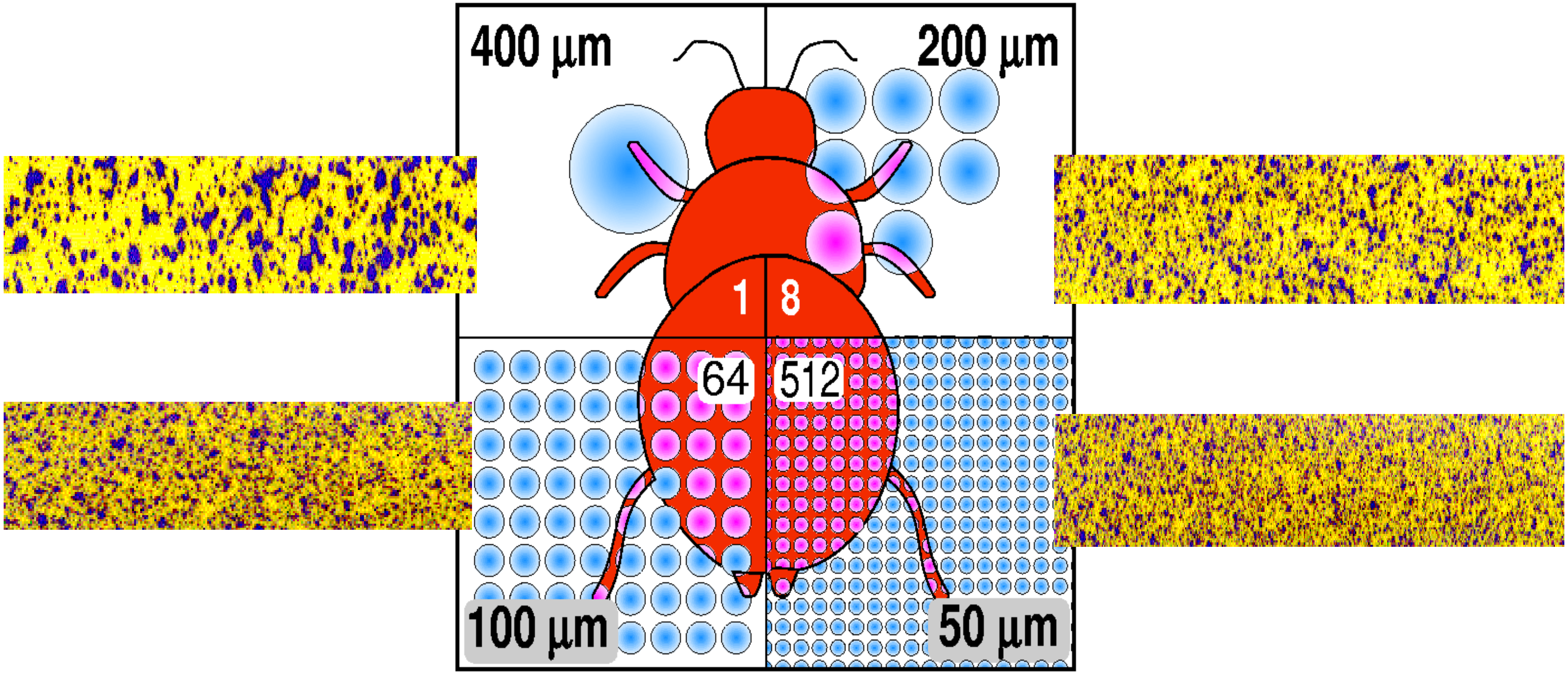
Avoid droplets < 100µ

Influence of wind velocity on spray drift (Disafa tests made in wind tunnel)



COVERAGE:

Small droplets can cover more area / cm^2

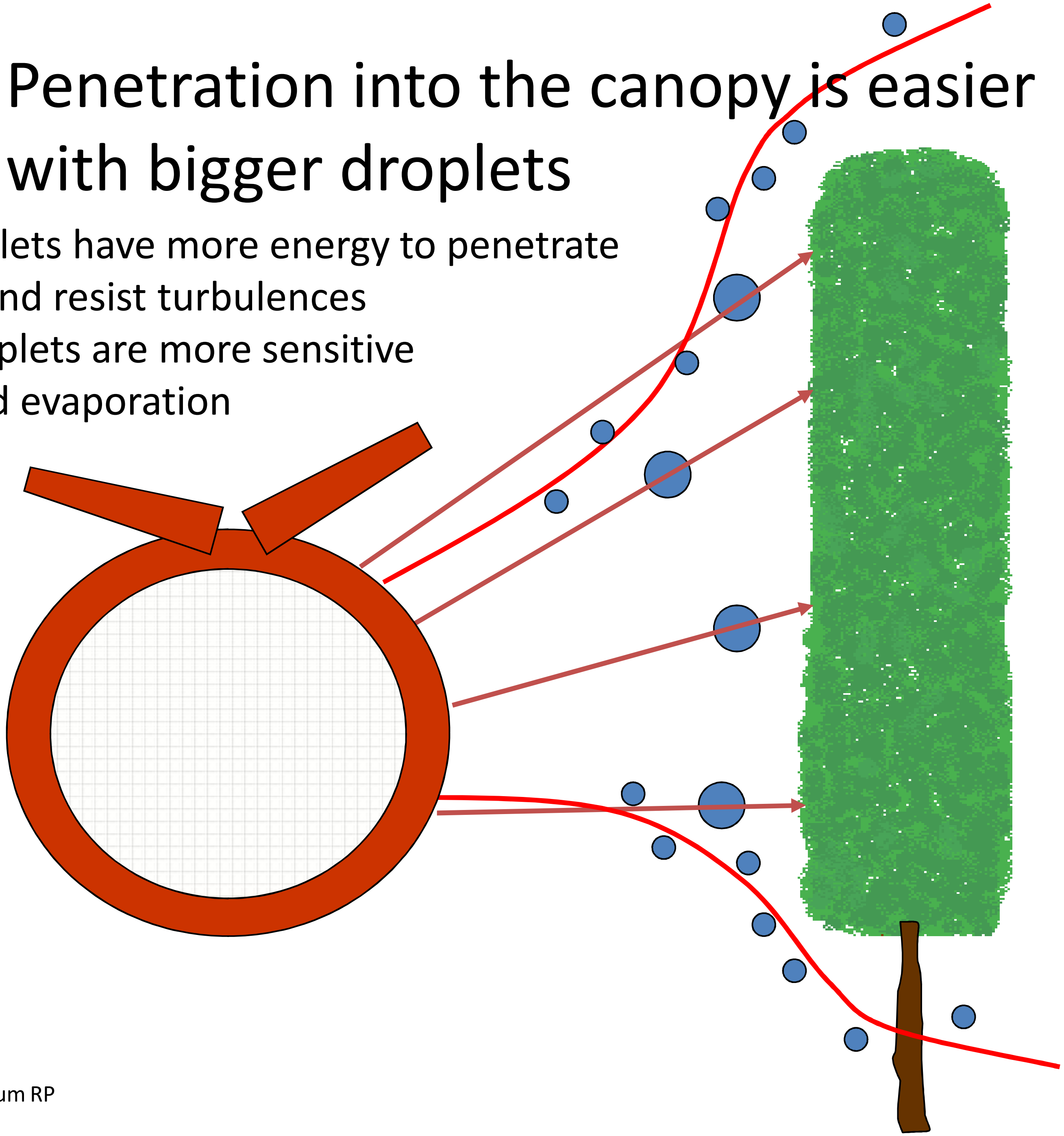


Biological activity depends on what is actually reaching the target and on the properties of the Plant Protection Product (small droplets often do not reach the target)

In drift sensitive areas small droplets should be avoided

Penetration into the canopy is easier with bigger droplets

- bigger droplets have more energy to penetrate the canopy and resist turbulences
- smaller droplets are more sensitive to wind and evaporation



Dienstleistungszentrum RP
Neustadt

Small droplets:
advantage and disadvantage

Advantage:

- Small droplets may have higher coverage on leaf area
- More even distribution of droplets
- Less risk of droplets runoff

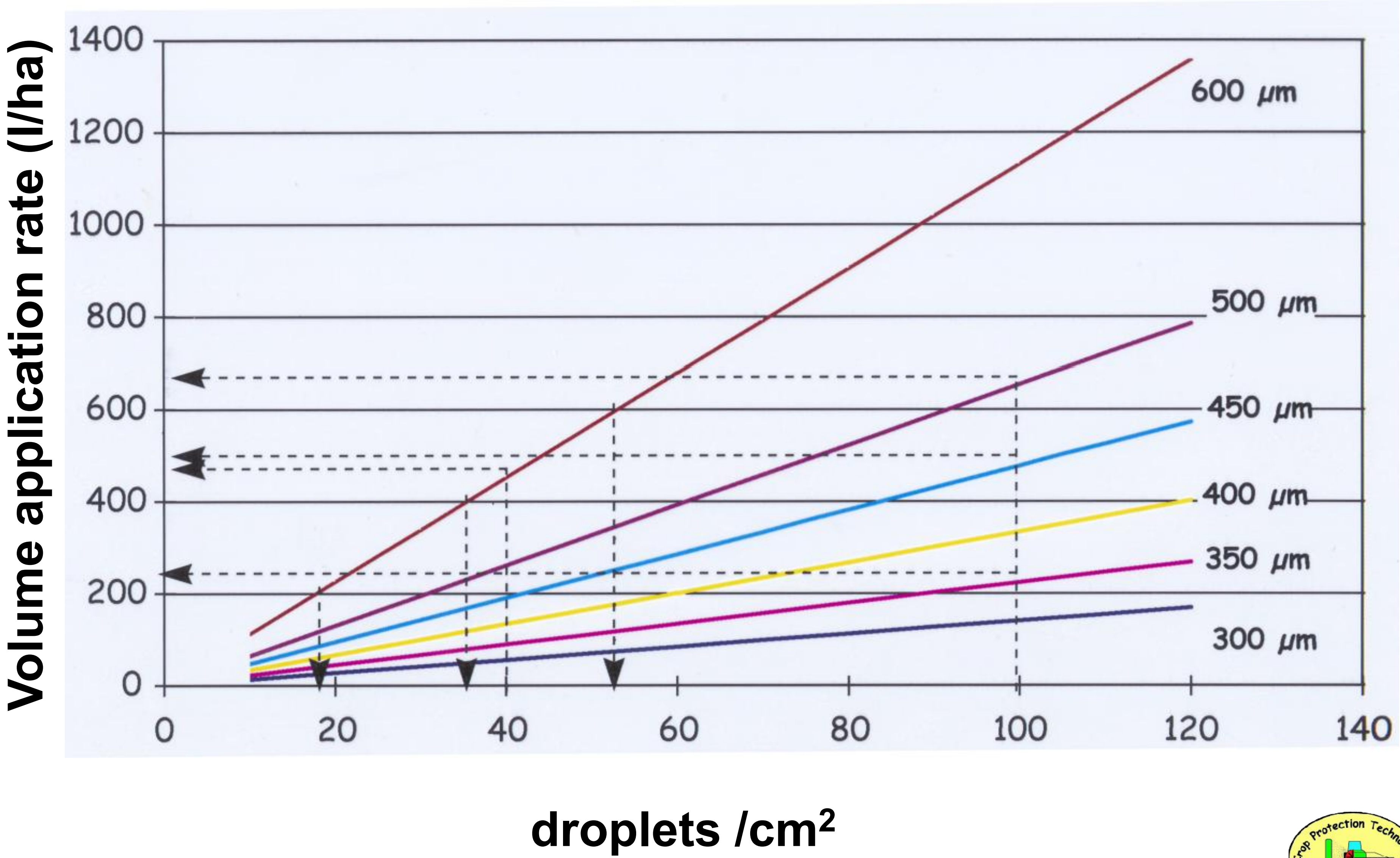
Disadvantage:

- higher risk of losses due to drift and turbulences
- Do not sufficiently penetrate canopy!
- Difficult depositing in canopy

RECOMMENDED DROPLET SIZE FOR DIFFERENT PESTICIDE CATEGORIES

Droplet size (µm)	Product type	Droplets / cm²
150÷-250	Fungicides	min 50÷70 droplets /cm^2
200÷250	Insecticides	min 20÷30 droplets /cm^2
200÷600	Herbicides	min 20÷40 droplets /cm^2

CORRELATION BETWEEN DROPLET SIZE, DROPLET/cm^2 AND VOLUME RATE



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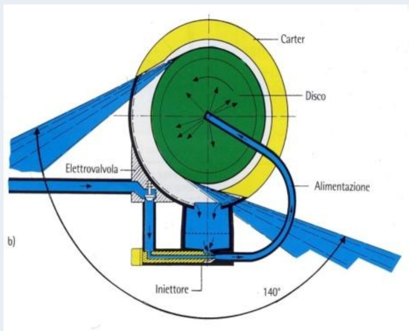
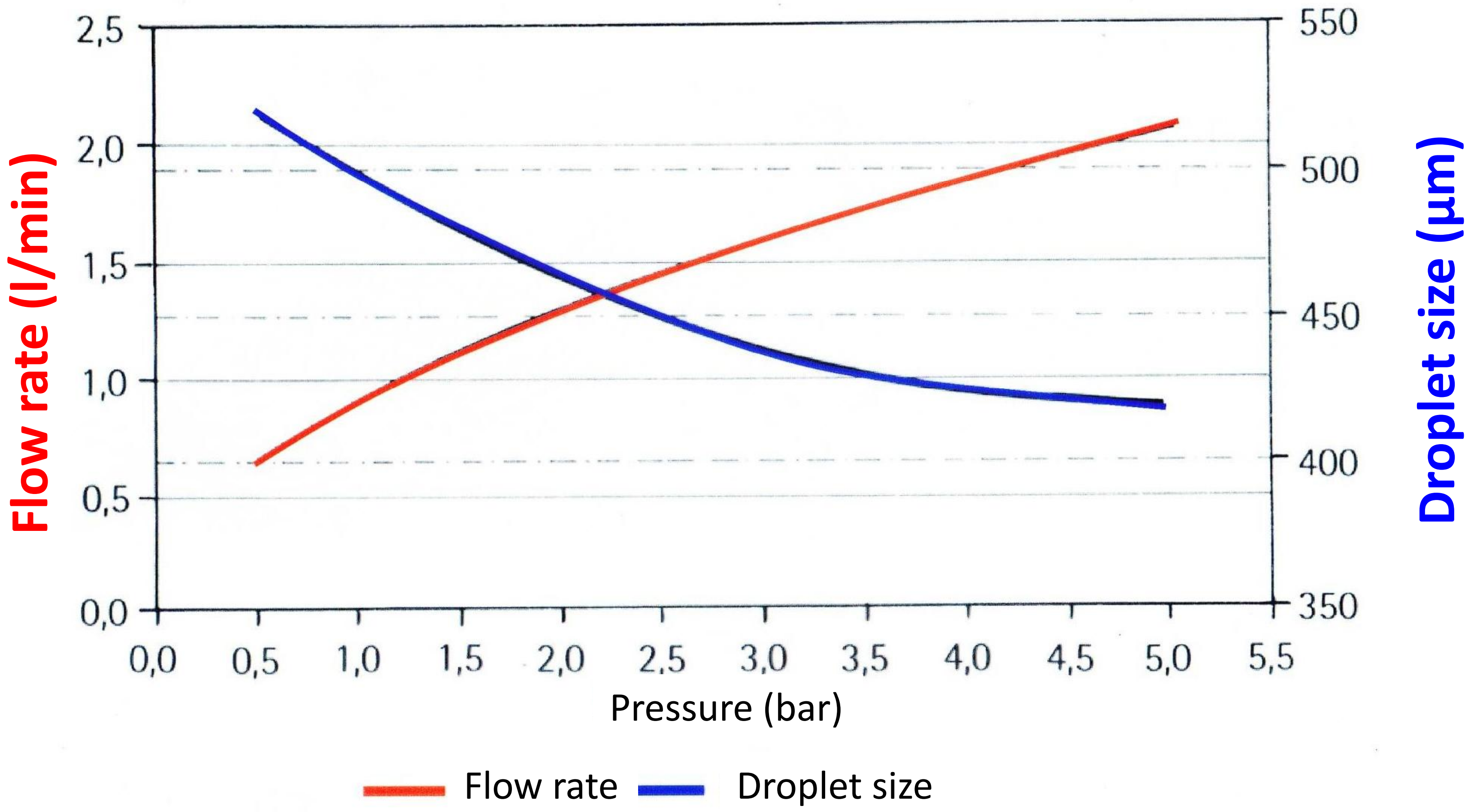
Drift reduction

Control droplet size !
(in drift sensitive areas
avoid droplets < 100 µ

Droplet generation

<table>
<tr><td>Hydraulic nozzle</td><td></td><td>• Droplets generated by driving a liquid through an orfice with pressure.
• easy adjustment of droplet size (nozzles)
• many types of nozzles</td></tr>
<tr><td>Pneumatic</td><td></td><td>• Droplets are generated by pressing air at high speed to a liquid stream
• Droplet size adjustment options low
• Often used in South EU</td></tr>
<tr><td>Rotation</td><td>
</td><td>• Droplet are generated through centrifugal force (spinning disc)
• Droplet size adjustmnent options very low</td></tr>
</table>

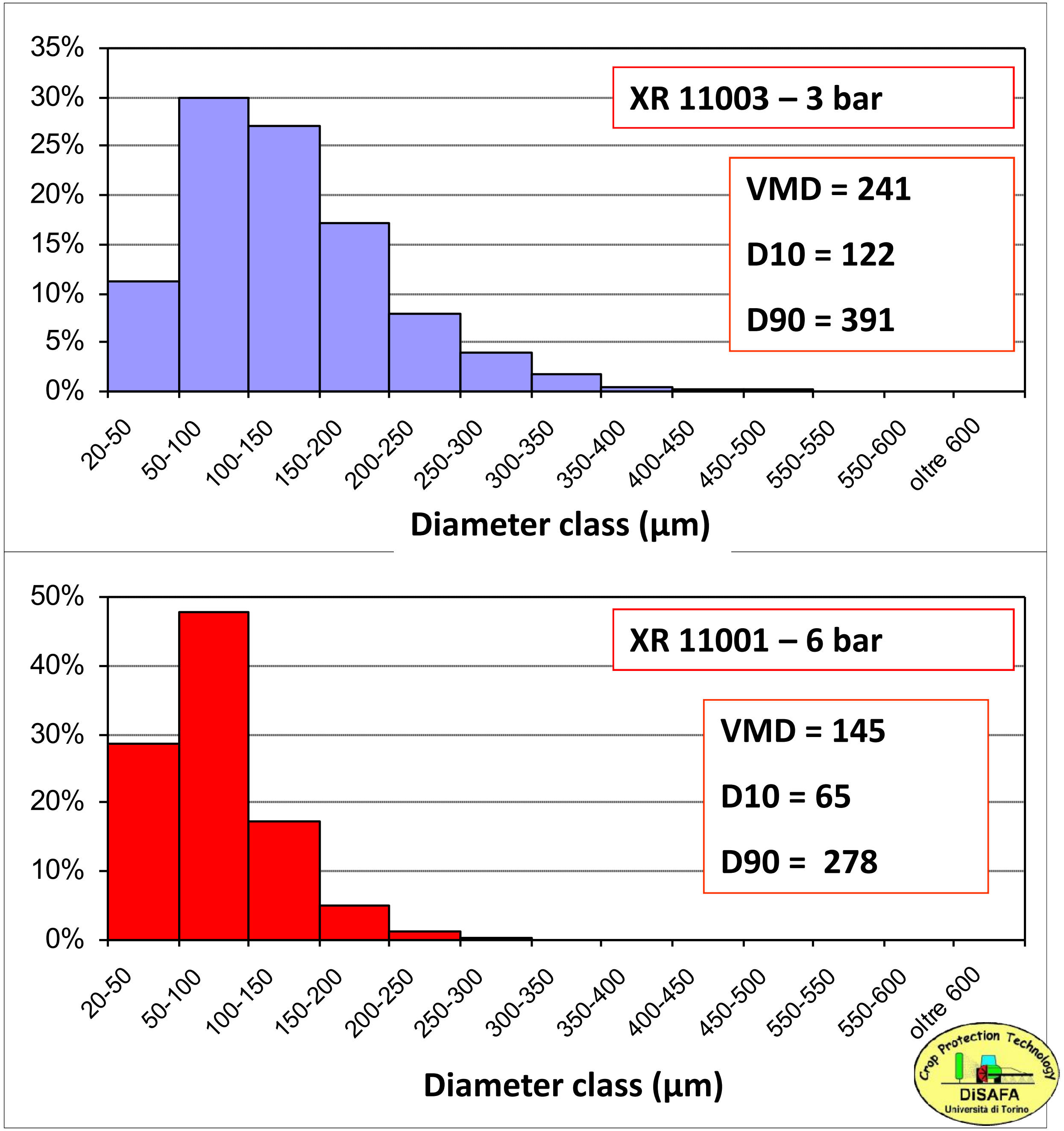
CORRELATION BETWEEN NOZZLE FLOW RATE, PRESSURE AND DROPLET SIZE



Nozzles produce a spectrum of droplets

Definitions:

- **VMD = Volume Median Diameter (volume 50% above/50% below value)**
- d 10 = droplet diameter under which 10% of the sprayed volume is contained
- d 90 = droplet diameter under which 90% of the sprayed volume is contained



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Is the VMD sufficient information to define the best nozzle to reduce drift?

… for decision making we should know how much volume is contained by droplets < 100 µ (0,1 mm) for each nozzle type

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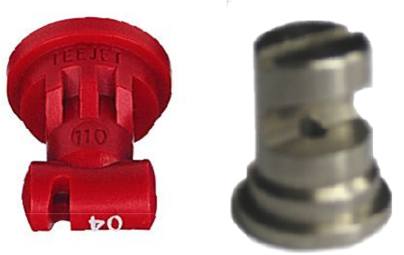
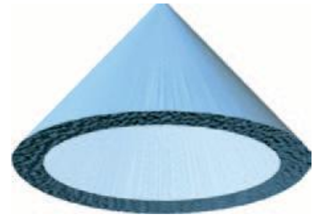
Hydraulic nozzles types

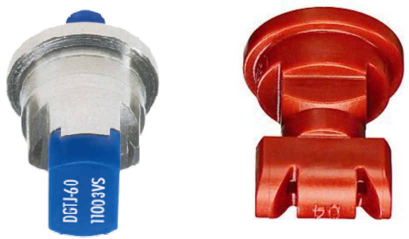
⇦ **Flatfan** ⇨



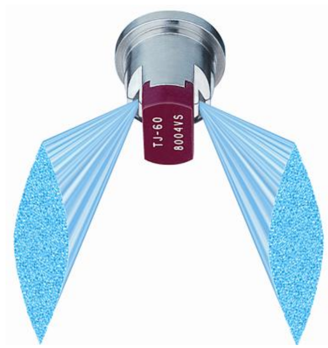
⇦ **Deflector nozzle** ⇨

⇦ **Hollow cone** ⇨

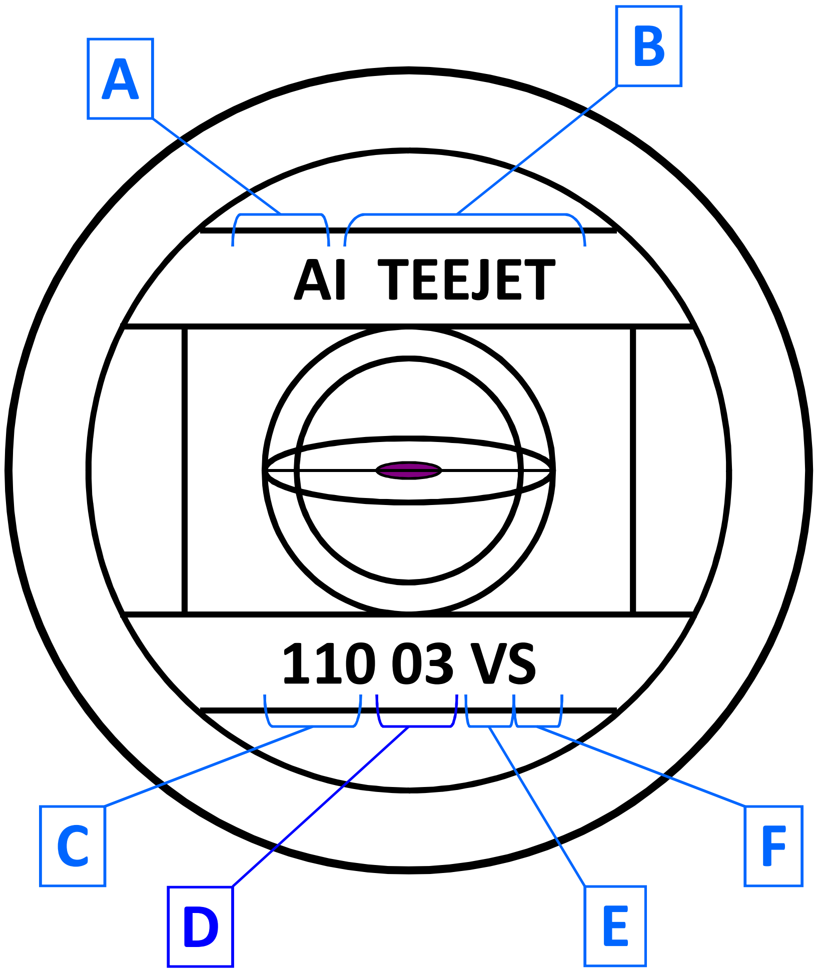




⇦ **Double flatfan** ⇨



Codeing of nozzles (Standard)



A: Nozzle type
(here AI = Air Induction)

B: Trade name
(here: Teejet)

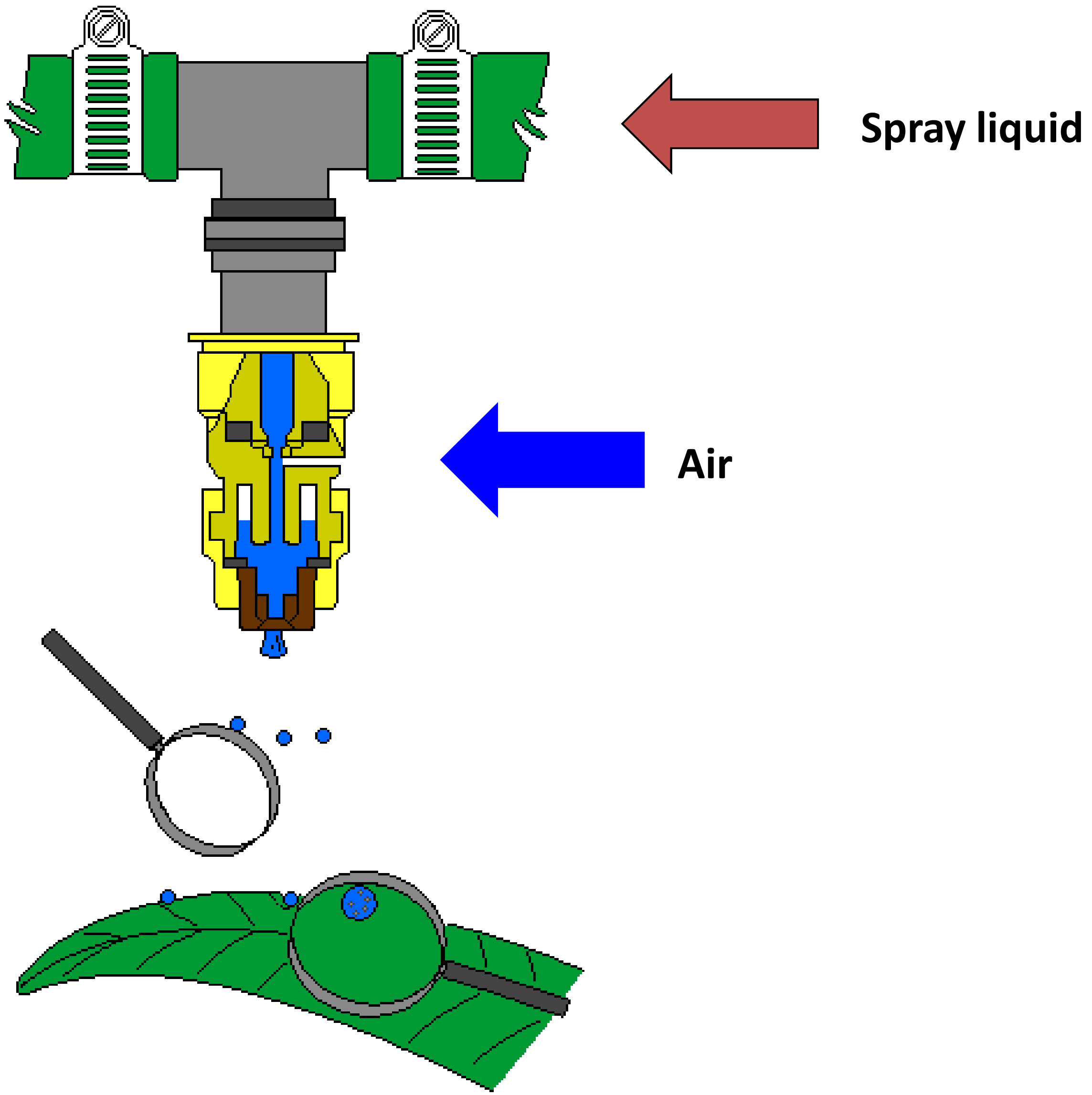
C: Spray angle
(here: 110°)

D: Nozzle output
(here: 0,3 Gallonen/min. at 40 psi;
= 1,1355 Liter/Min. at 2,8 bar)
⇨ größere Zahl = größerer Ausstoß

E: Colour code (related to the flow rate)
(V = VisiFlo-Code [ISO-Norm])

F: Nozzles material
(here: S = stainless steel),

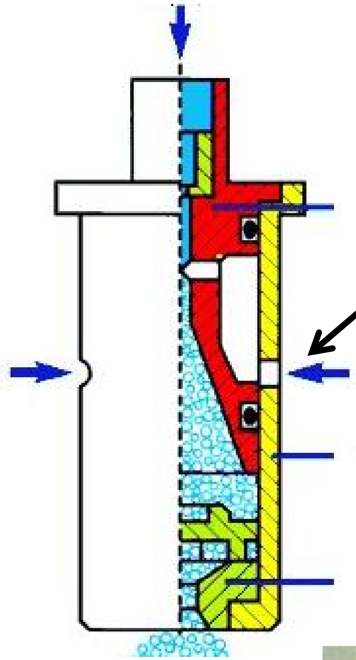
Air induction nozzle – Droplets with air inclusions



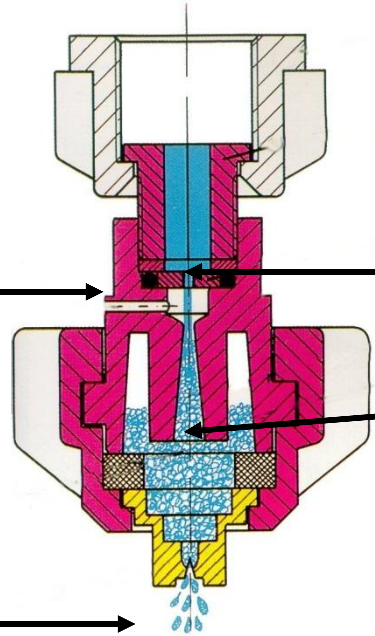
Source: Agrotop

ANTIDRIFT NOZZLES

Liquid entrance



Air suction hole



Disc for dosing liquid flow rate

Mixing chamber

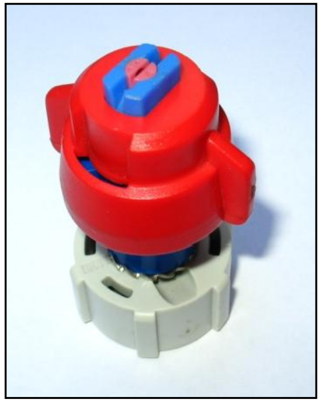
Liquid output

Air induction

Turbodrop

No disadvantages of Antidrift nozzles

TurboDrop



ID 90-xx

AVI 80-xx

IDK 90-xx
CVI 80-xx

- Large number of trials show comparable biological activity for most PPP
- Perceived disadvantage: not visible spray cloud

Modern Nozzles in Field, Vine and Orchards applications

Advantage of Injector and Antidrift nozzles:

- more coarse droplet spectrum 300 to 500 µ (VMD)
- at the same flow rate as traditional nozzles (Spray volume /ha)
- very low fraction of fine droplets Ø < 100 µm (< 1 %)

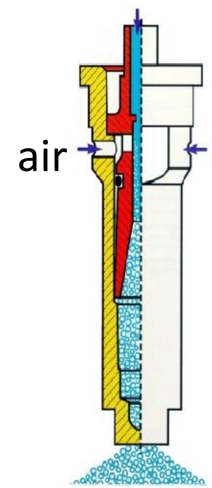
→ Reduces spray drift up to 95 %
(see Nozzles classification ; different in countries)

Key recommendation: reduce drift by reducing small droplets – Antidrift nozzles

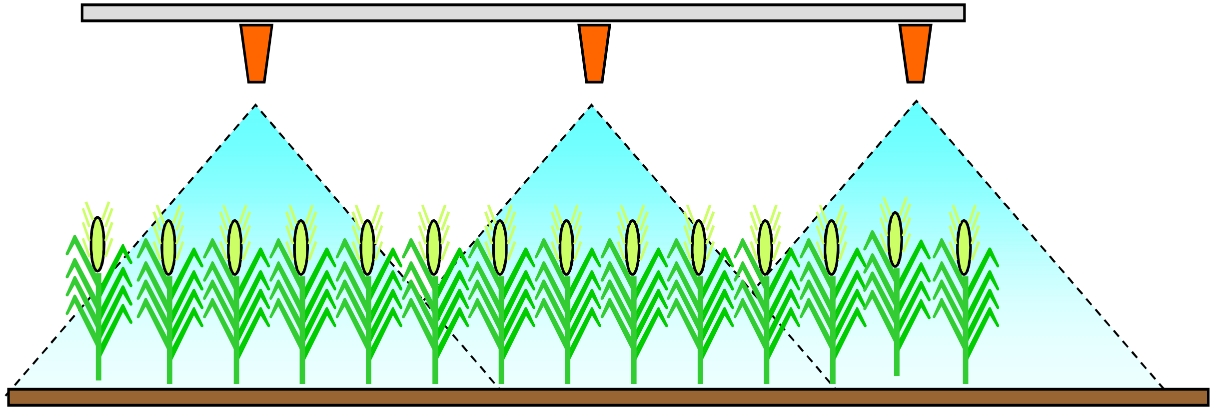
On both sides of the sprayer: same volume output

THE PRESENT SITUATION IN EUROPE CONCERNING SPRAY DRIFT REDUCING TECHNIQUES

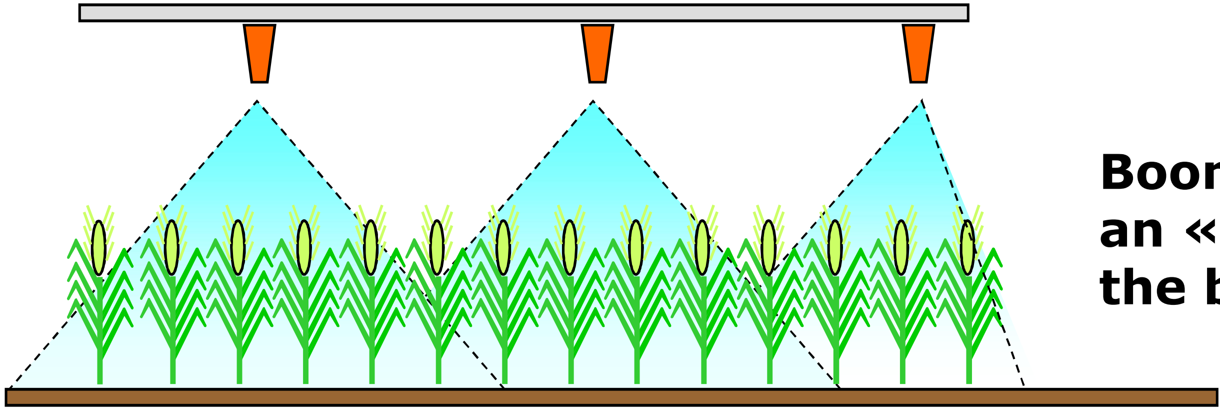
- **AIR INDUCTION NOZZLES** ARE THE MOST SPREAD DRIFT REDUCING TECHNIQUE ON SPRAYERS
- THEY ARE **MORE COMMON ON FIELD CROP SPRAYERS**, ESPECIALLY IN NORTHERN EUROPEAN COUNTRIES
- STILL **POORLY USED ON AIR-ASSISTED SPRAYERS** IN ORCHARDS AND VINE APPLICATIONS



END BOOM NOZZLES



Traditional boom



Boom equipped with an «asymmetric jet» at the boom end

Drift reduction = 10-20%

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Selection of the right nozzle
Consider

- Crop
- Droplet size
- Environmental requirements
- Spray volume
- Weather conditions
- Driving speed
- Pressure
- PPP

Drift reduction

reduce the distance to the target

lower chance for the wind to interfere

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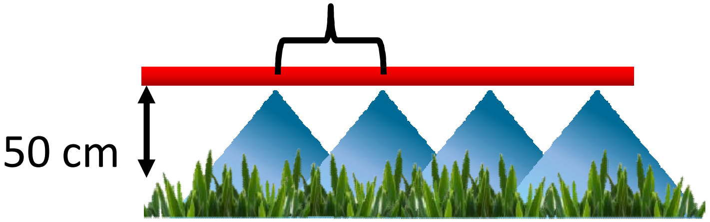
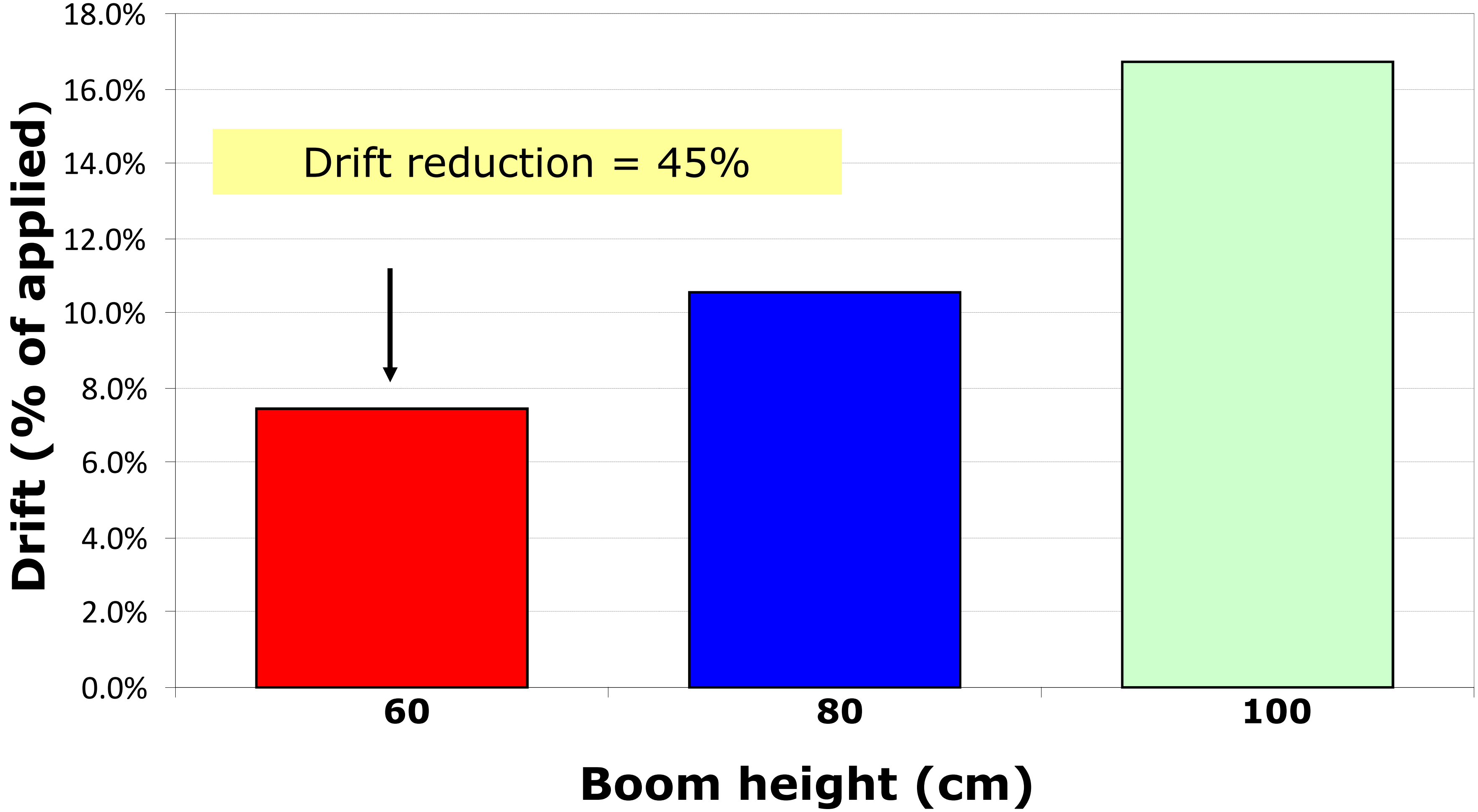
Boom height at spraying is often to high

Nozzle spacing
50 cm

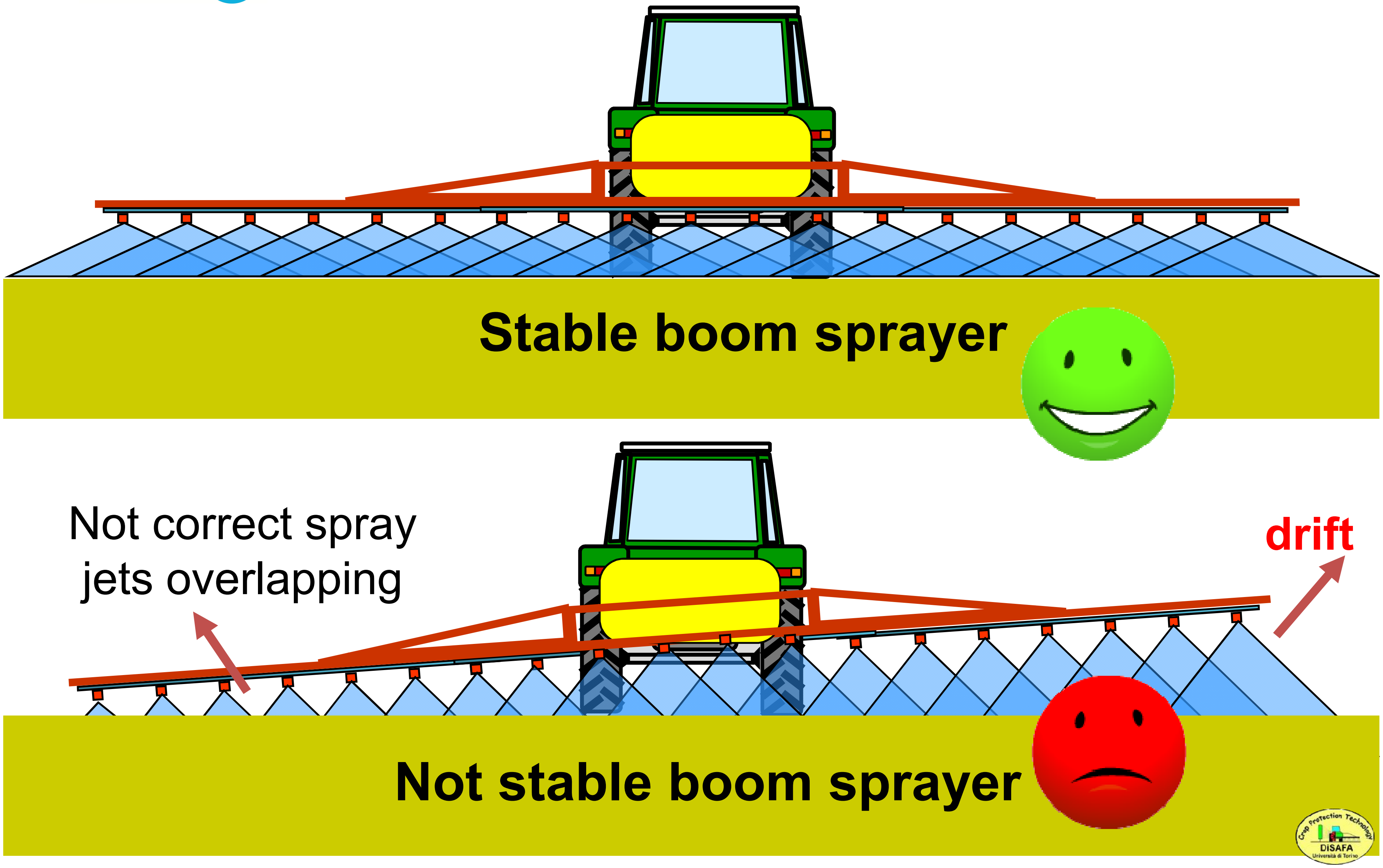


.... It is easy visible if the boom is to high !

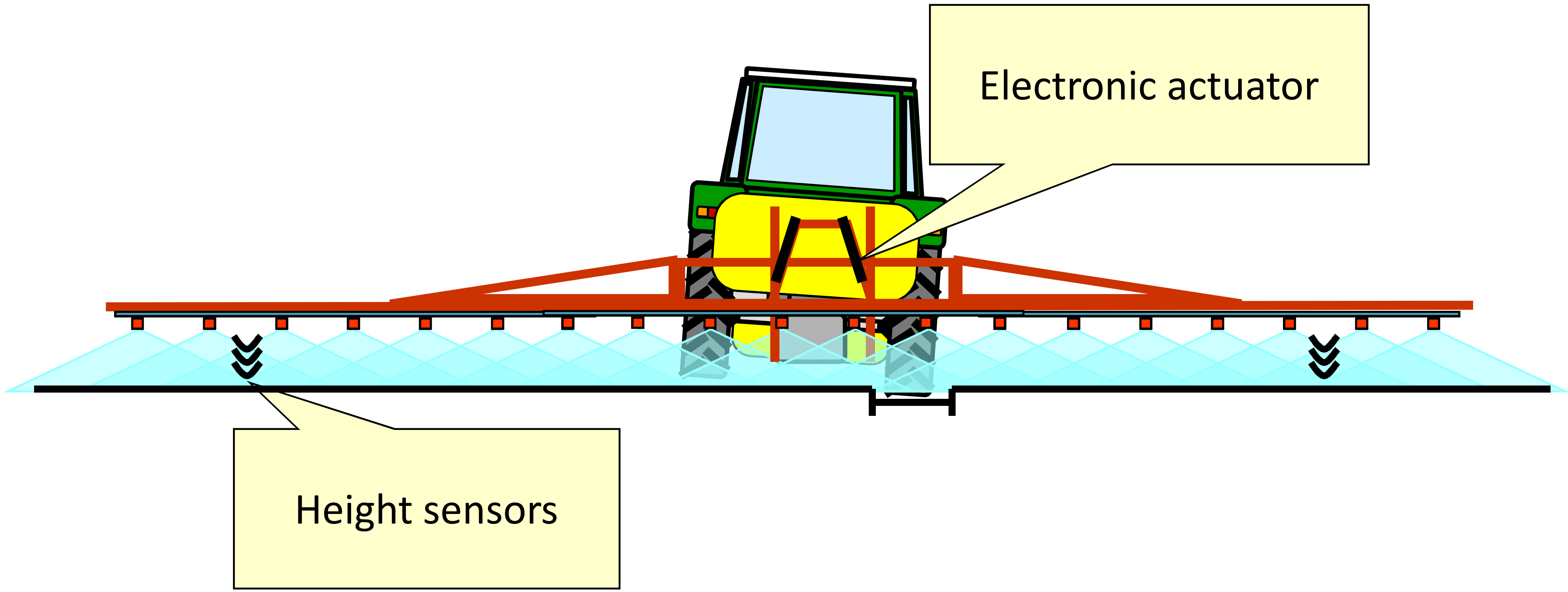
Correct boom height is important to reduce spray drift risks



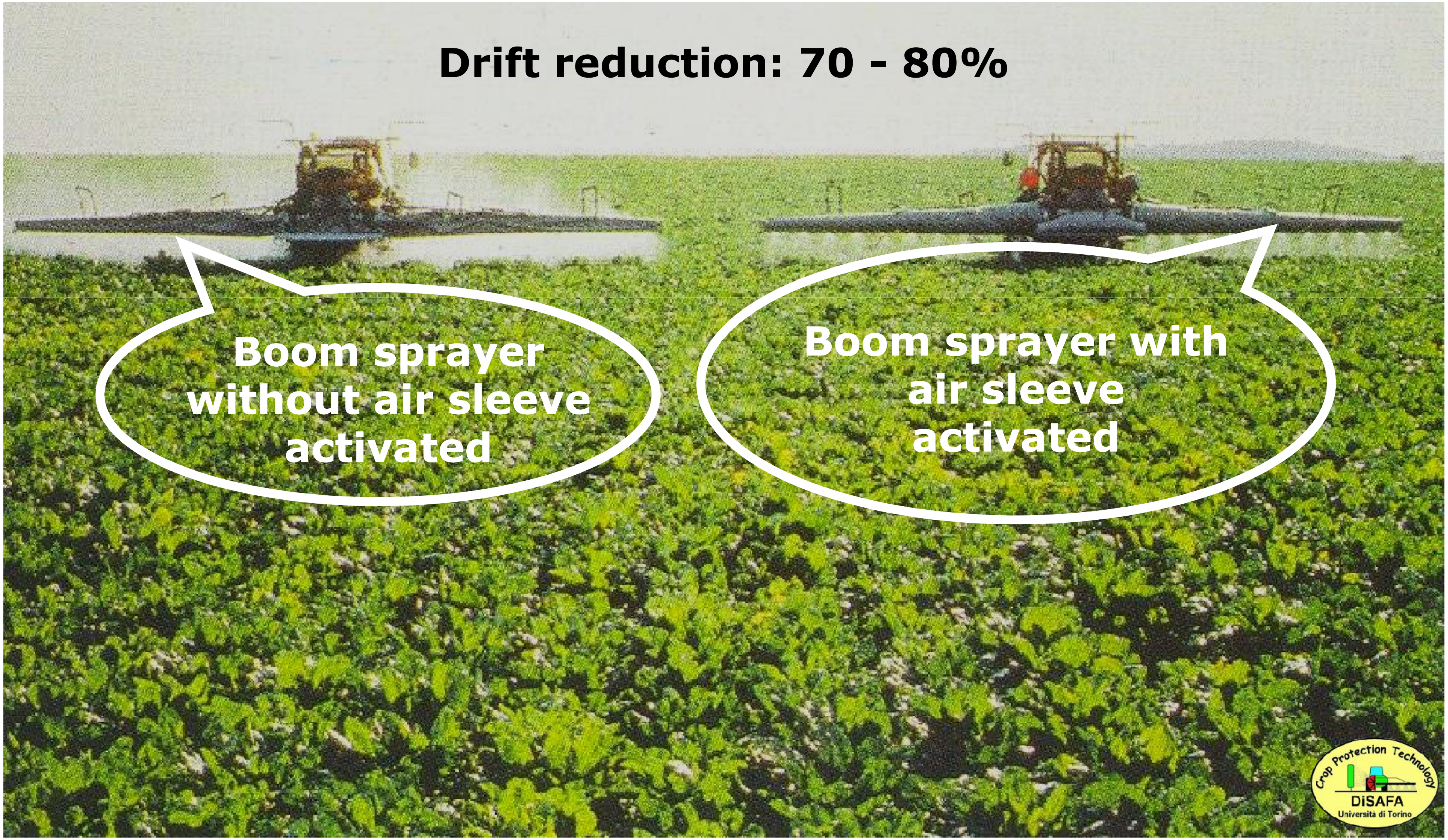
Pay attention to boom stability to reduce the spray drift risk



Automatic control of boom height



In often windy areas air support could help to reduce spray drift



Droplegs reduce the distance to the target

SHIELDED BOOM SPRAYERS

Drift reduction: 80 - 90%

BAND SPRAYER COMBINED WITH SOWING AND WEEDING MACHINES

Drift reduction:
60 - 70%

Shielded sprayer in orchards

- Training systems need to be aligned
- Driving not always possible or difficult
- Sprayer cleaning complex (point source ?)

Drift reduction

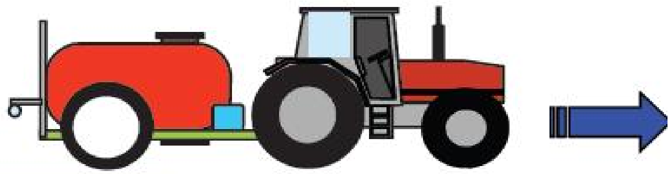
reduce the forward speed

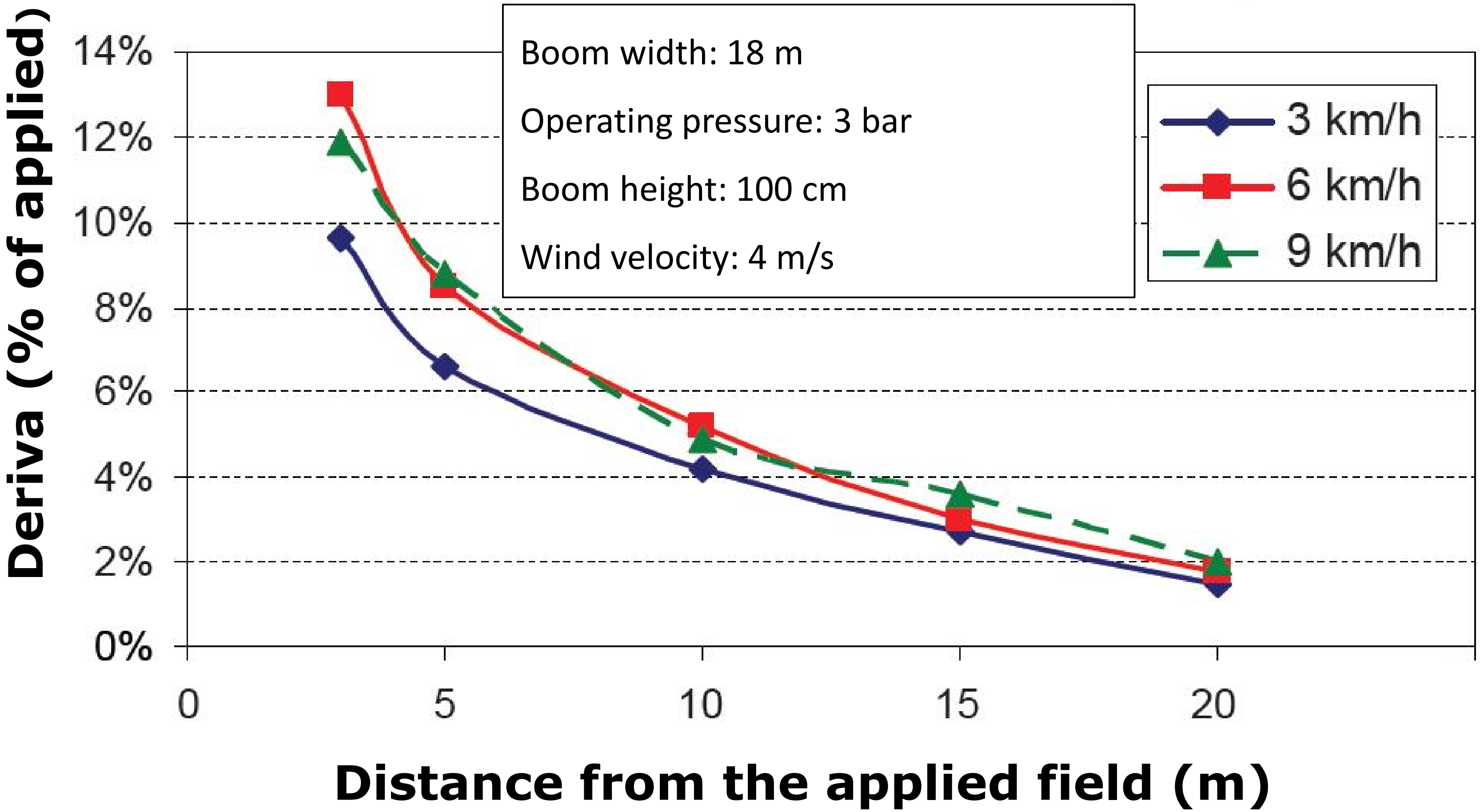
lower chance for the wind to interfere

Driving Speed for spraying along sensitive areas should not exceed 8 km/h

8 km / h is the reference speed for nozzle drift classification (DE)

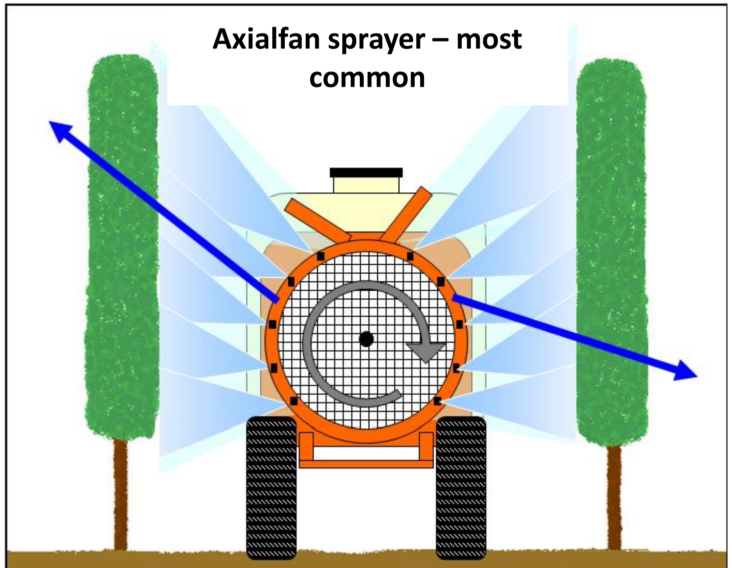
ADEQUATE FORWARD SPEED





Additional complexity to reduce drift in Orchard , Vine and Bush crops

Orchard / vine sprayers transport droplets by air to the targets

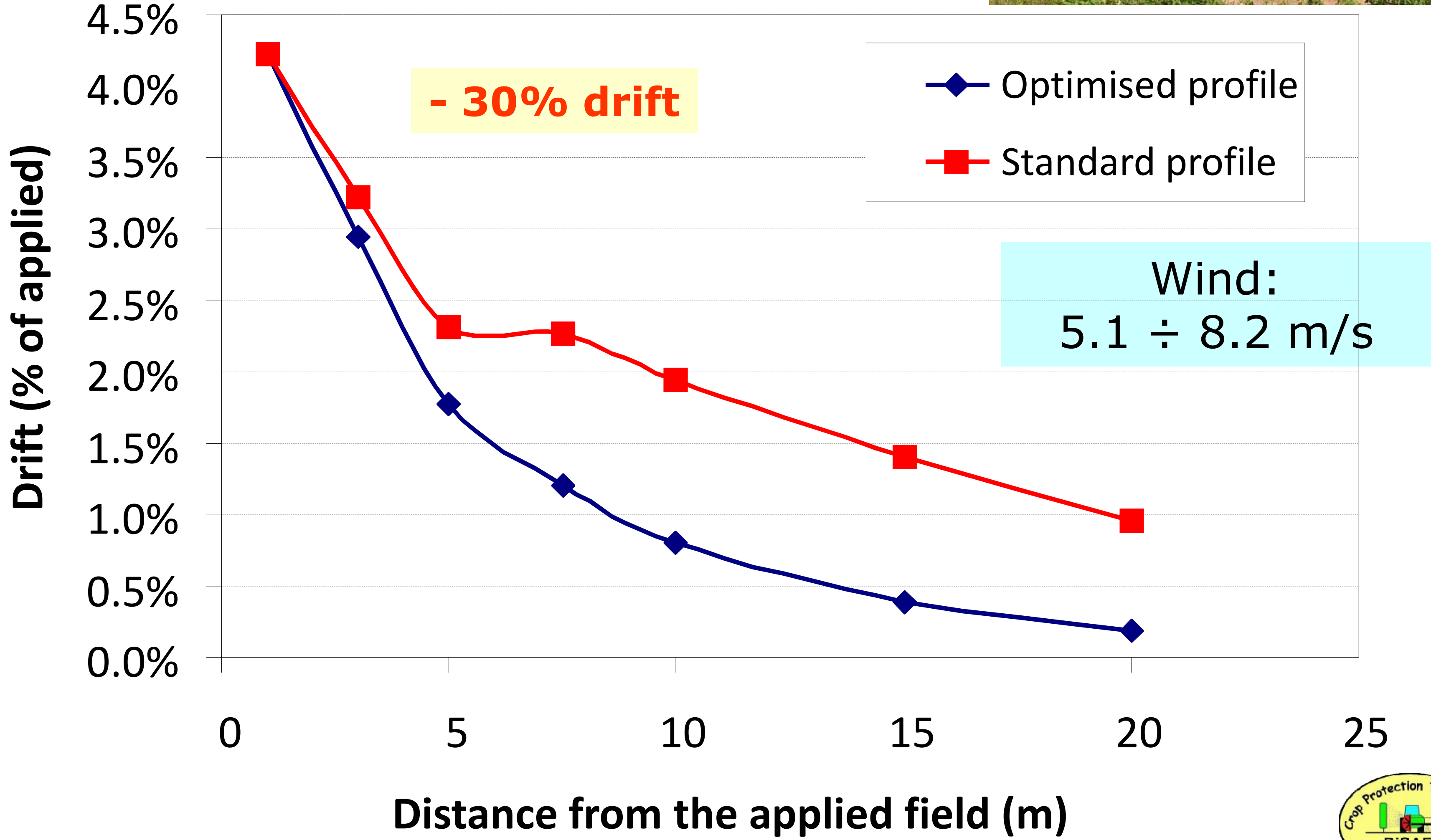


- Most commonly used are sprayers with axial fans
- Produce unsymetric air flow
- Distances to the target for the droplets vary strongly
- Spray profil must be adapted according the training system of the crop and the different seasonal development.

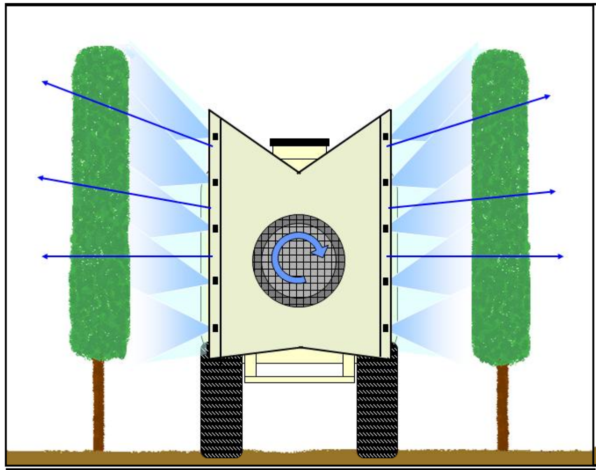
General observation:
Often applications are done with to much air volume.
More easy technical adjustment possibilities on sprayers would be beneficial
Sprayers are often not well adjusted.

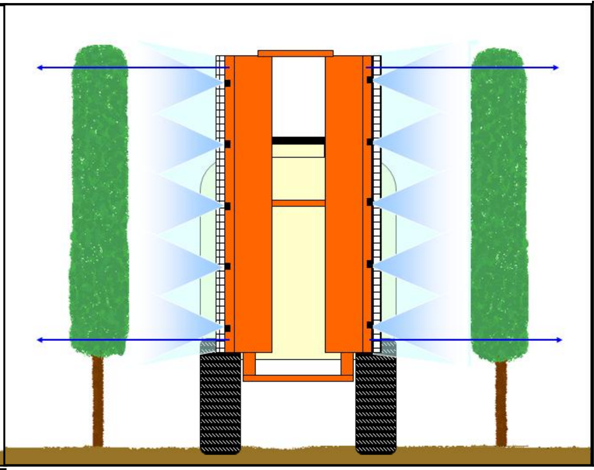
Example: vineyard before flowering (LAI 0.3)

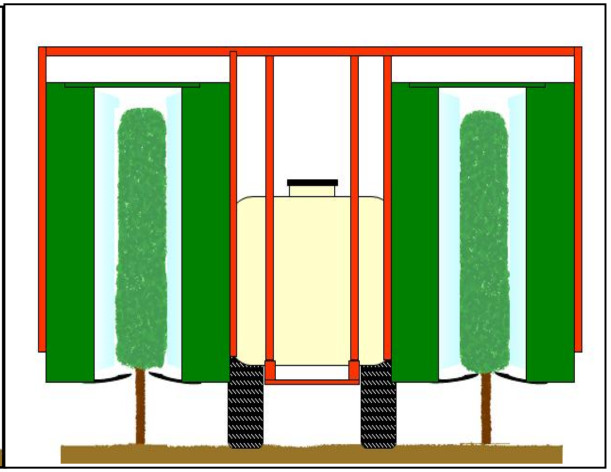
Conventional axial fan sprayer



Sprayer types which reduce the distance from droplet generation to traget







Axialfan sprayer with crossflow installation • distance to target more equal •Air directed to canopy Pictures: Ipach DLZ-Rheinpfalz	Tangential- fan sprayer • distance to target more equal •Air directed parallel to canopy	Tunnel sprayer • drift is collected by shields • Special training of crop is necessary / cannot operate everywhere

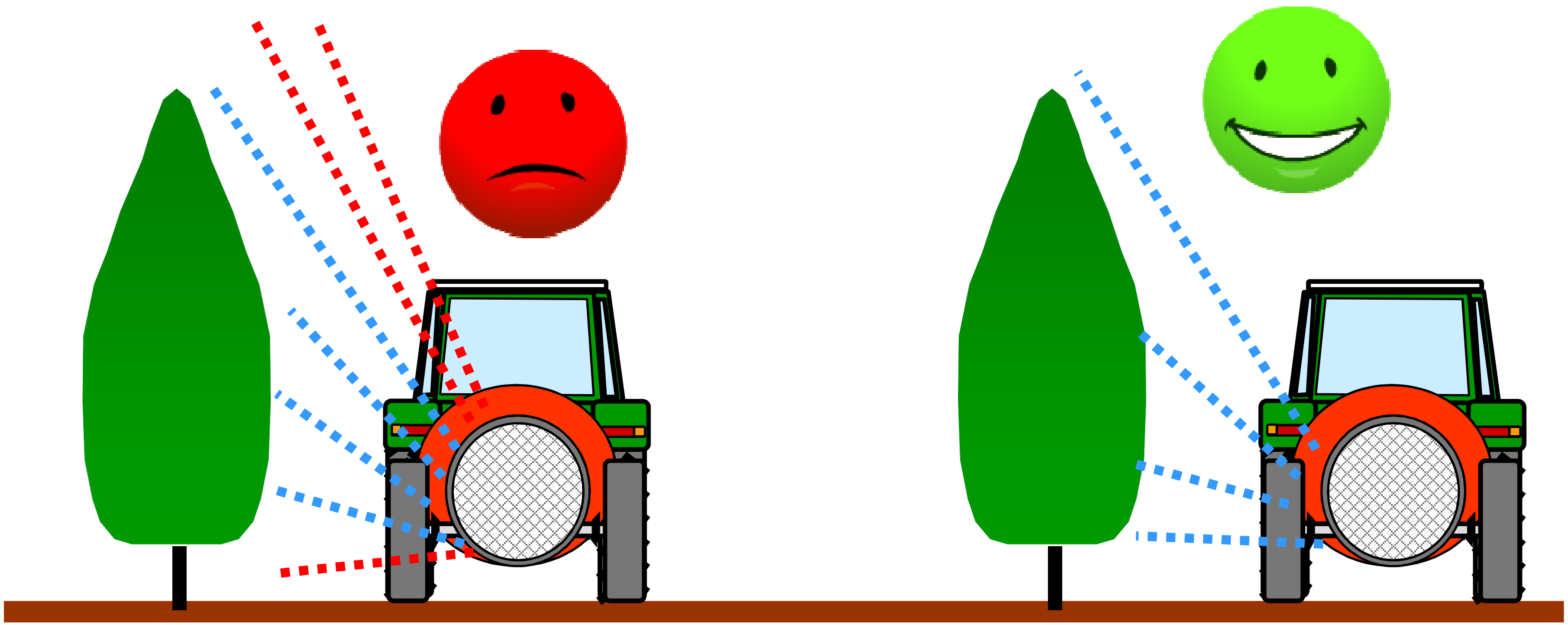
Measurement of drift reduction concentrates on complete sprayer and its configuration – a challenge for drift classifications

Sprayer adjustment is key for drift reduction mainly in orchard /vine crops

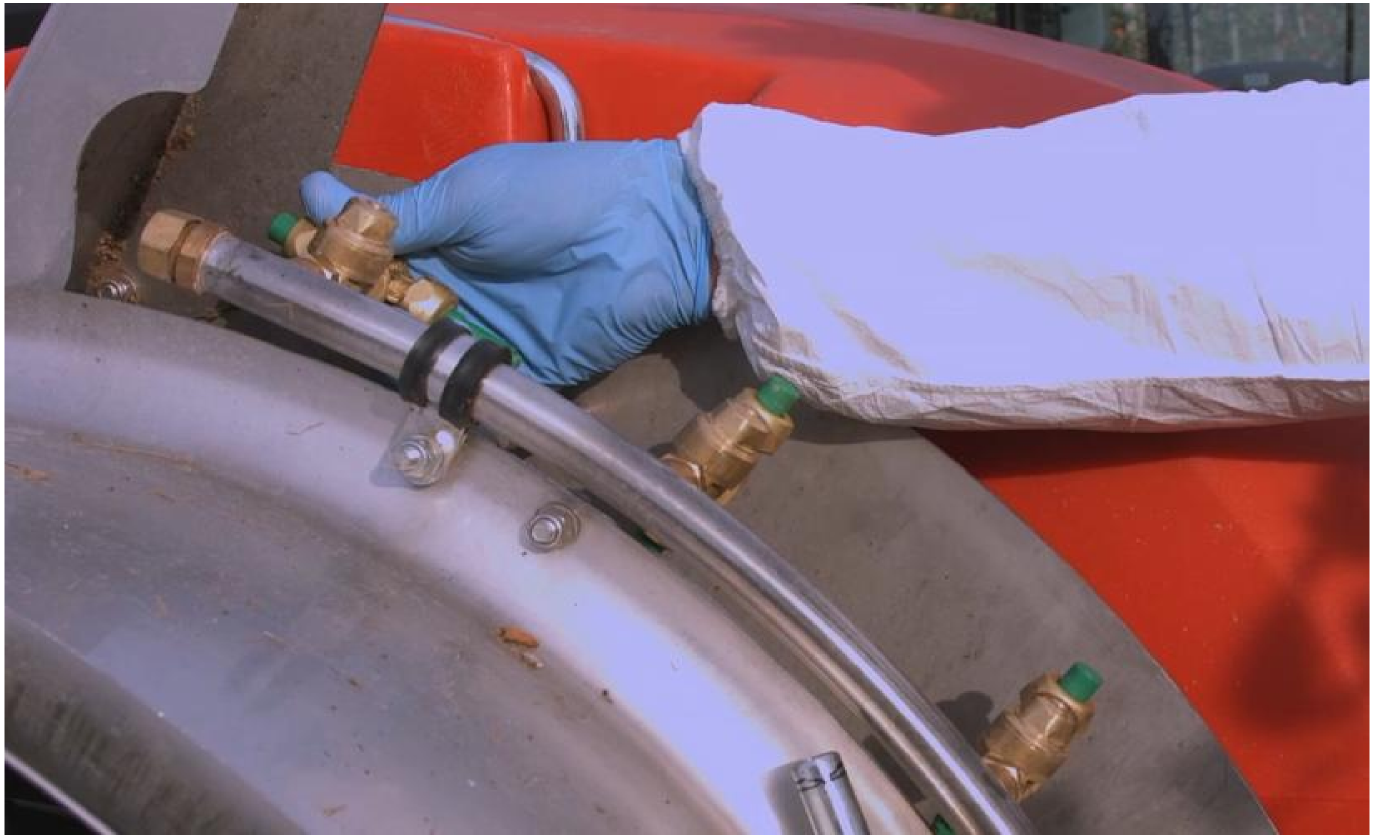
Key aspects

- Droplet size (nozzles)
- Air direction
- Air flow / speed
- Air volume

Adjust sprayer correctly to the canopy structure
Nozzle orientation

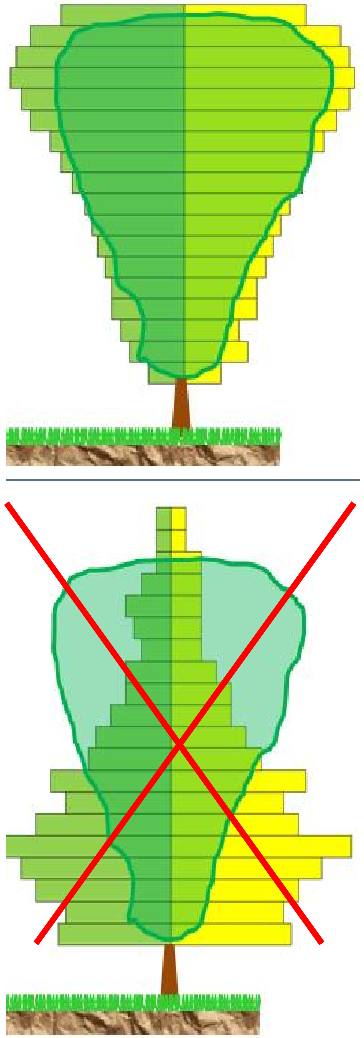


Close nozzles you do not need or change as required



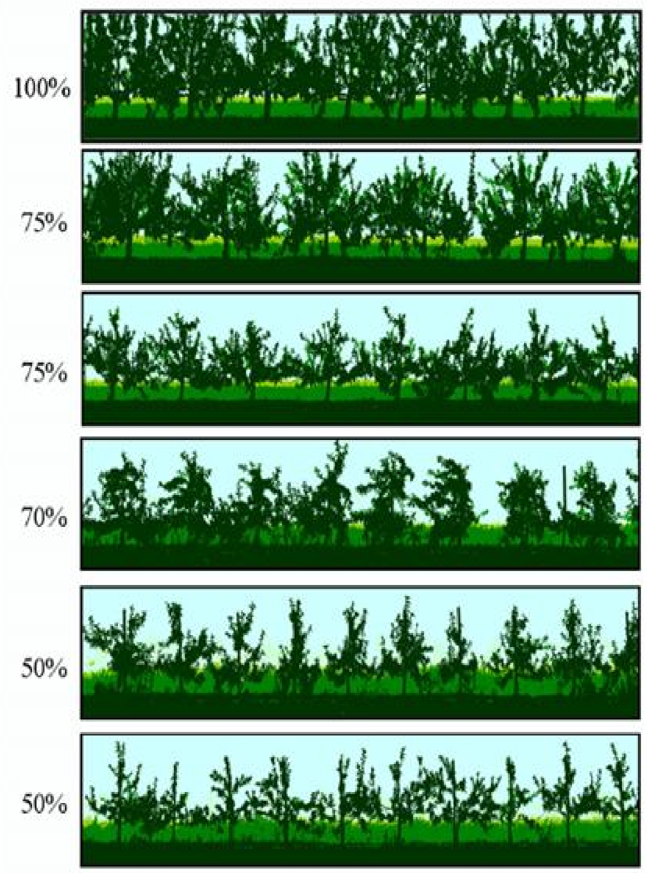
…. Change nozzle by turning the nozzle holder

Adjust the sprayer to the canopy profile needed



Big challenge is the correct adjustment of the spray output to the crop canopy

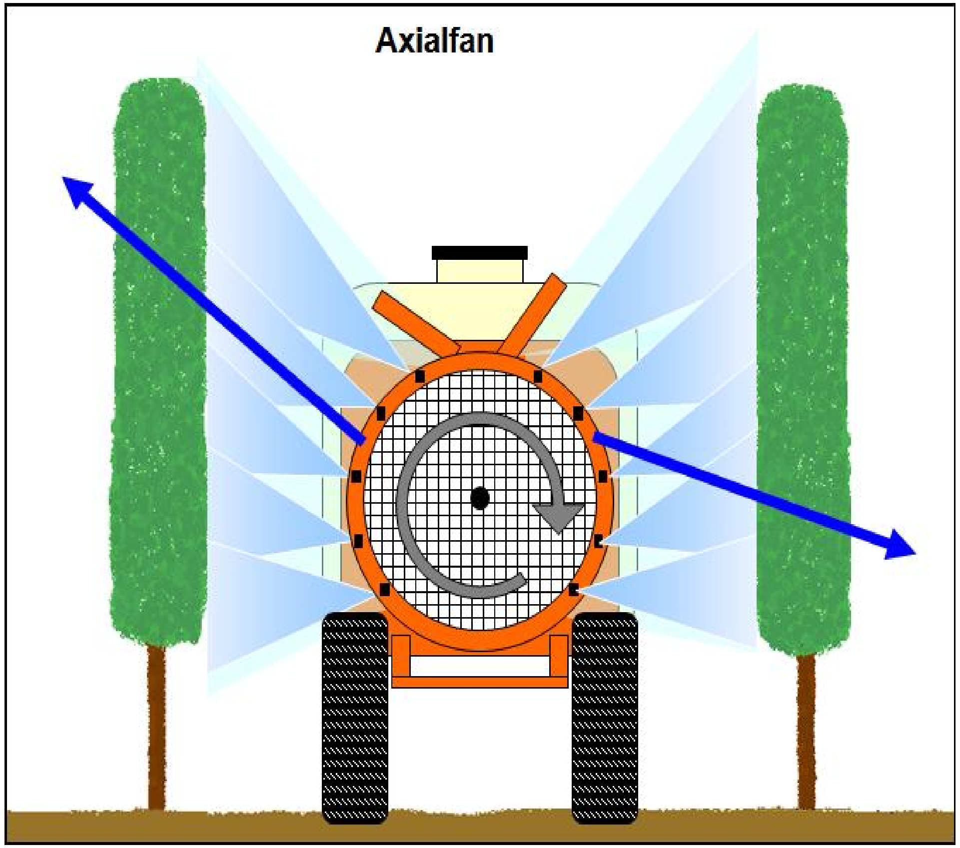
- spray volume need to cover and penetrate the shape and structure of the canopy
- nozzles with different spray output need to be arranged to fit the canopy
- Several adjustments needed during the season as canopy develops



The images shared by courtesy of Health and Safety Executive – UK. Walklate et al .2003.

Adjust air precisely to the crop canopy

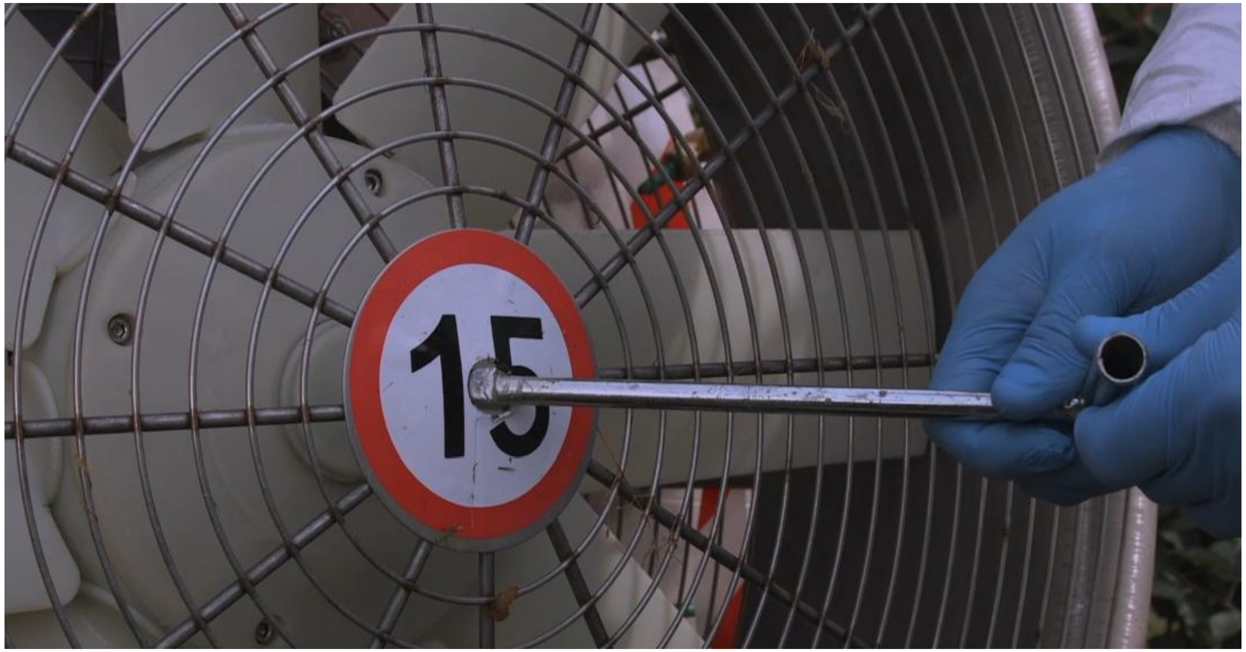
More air upwards



More air downwards

Adjustment through correct setting of deflectors
Adjustment of axial fan sprayers is difficult

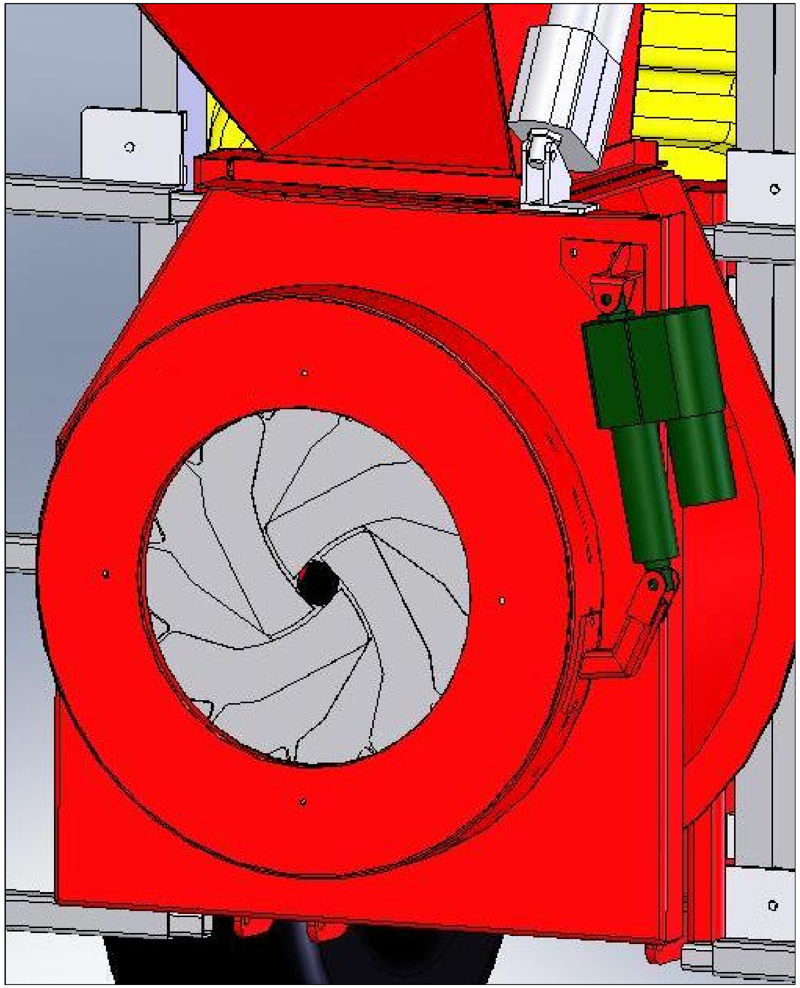
Air flow and volume adjustment



- Change the angle of the blades of the wind machine
- Air volume mainly adjusted via gear box / Pto

AIR-ASSISTED SPRAYERS EQUIPPED WITH ADJUSTABLE FAN AIR INLET

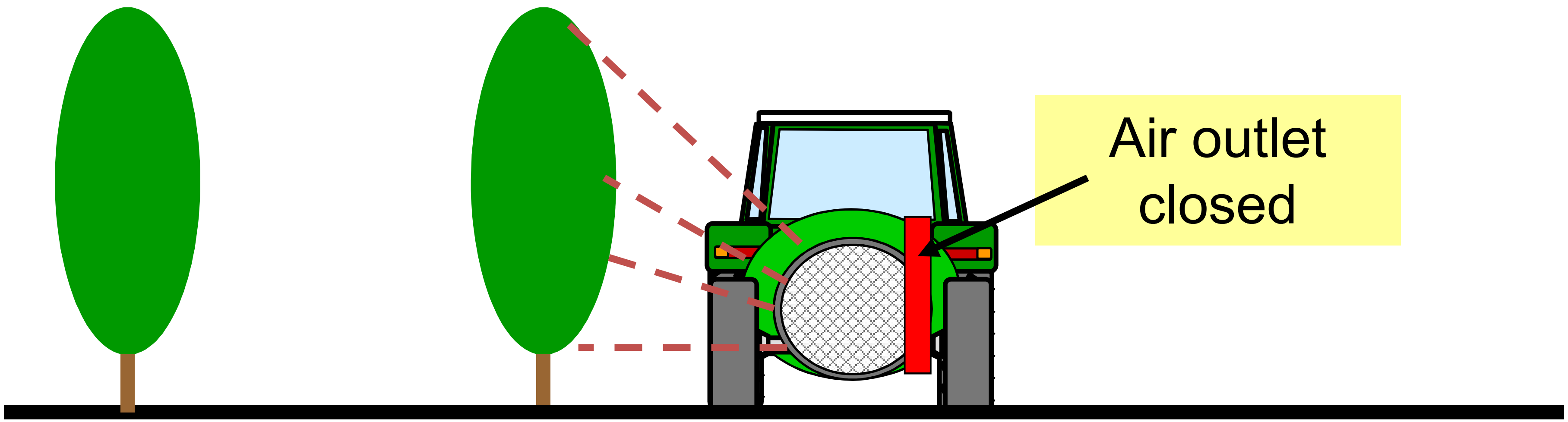
Adjustment of AIR FLOW



- **diaphragm leaf shutter**
  - ⇨ restricting airflow on fan inlet

AIR-ASSISTED SPRAYERS EQUIPPED WITH AIR CLOSURE SYSTEMS ON ONE SIDE

Drift reduction: 20-30%



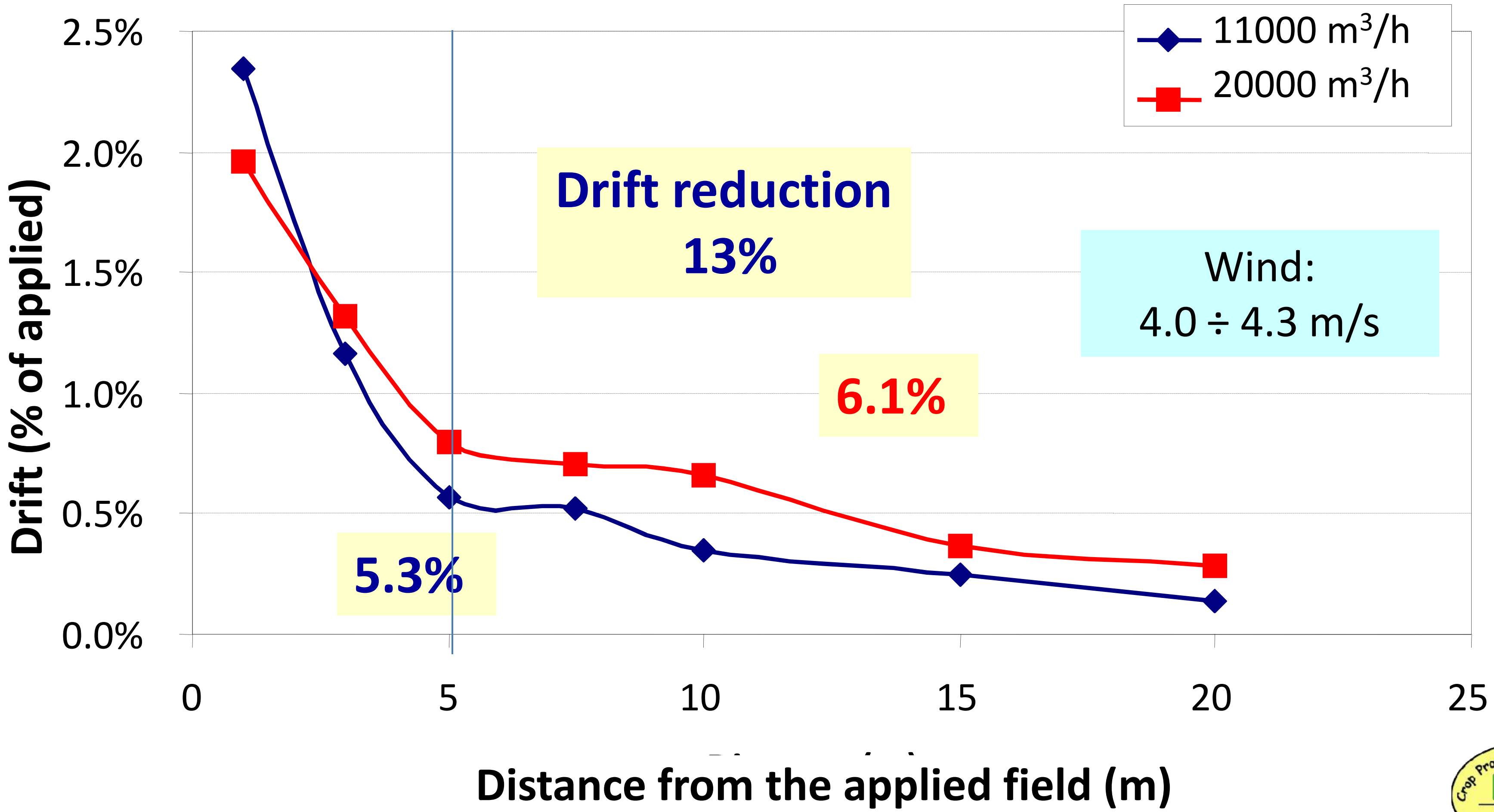
TOPPS Water Protection

AIR-ASSISTED SPRAYERS EQUIPPED WITH AIR CLOSURE SYSTEMS ON ONE SIDE

Crop Protection Technology
DiSAFA
Università di Torino

ADJUSTMENT OF FAN AIR FLOW RATE

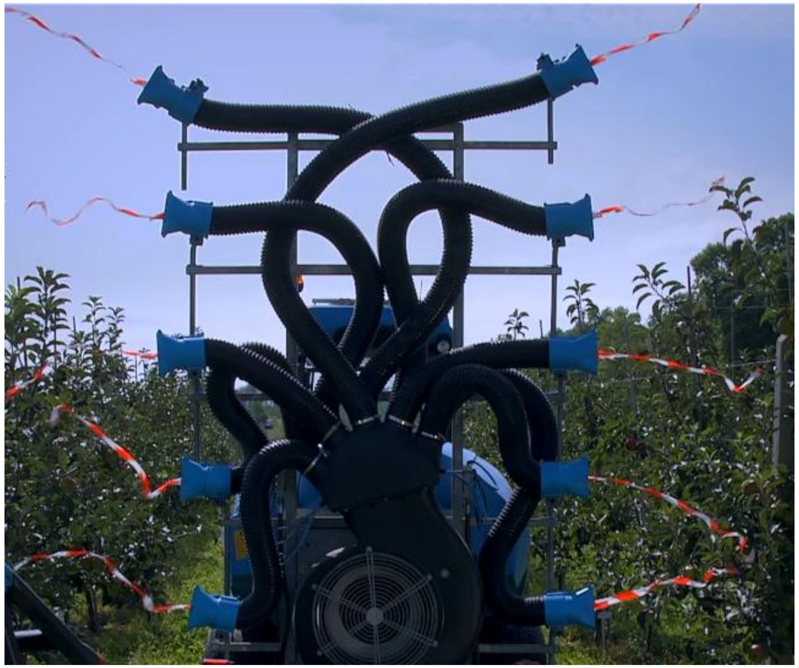
Air flow rate adjustment to the vegetation development operating enables to limit the overall spray drift, especially after 5 m



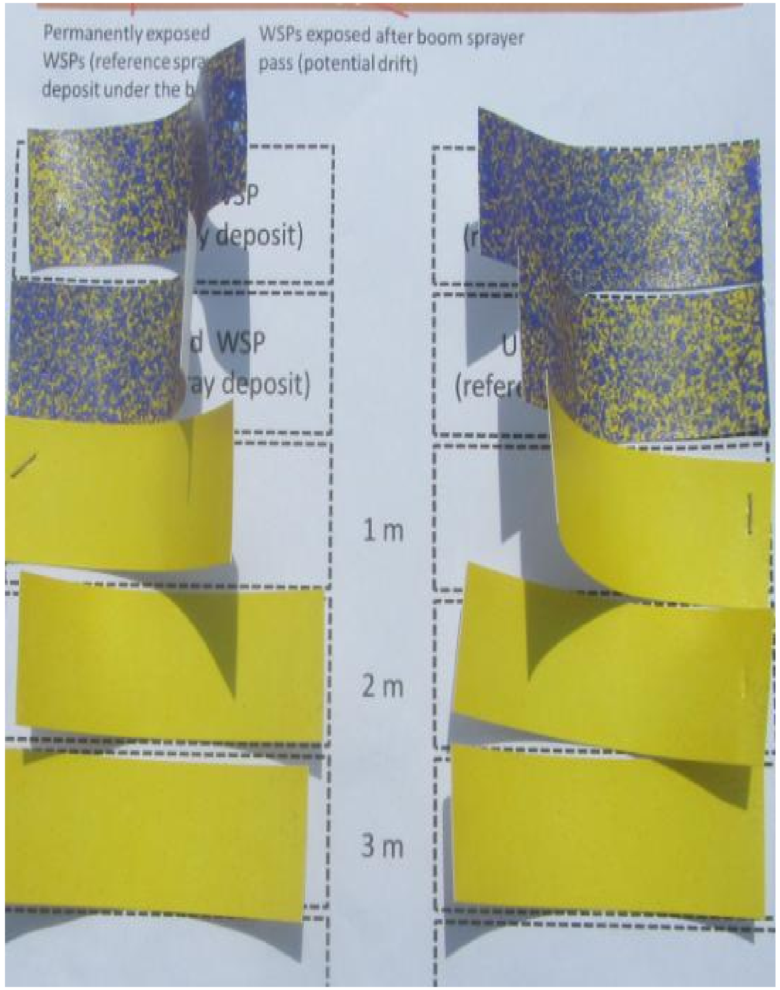
TOPPS Water Protection

How to adjust in practice

How to adjust in practice



Avoid losses of spray – biological activity



Measuring poles with water sensitive paper

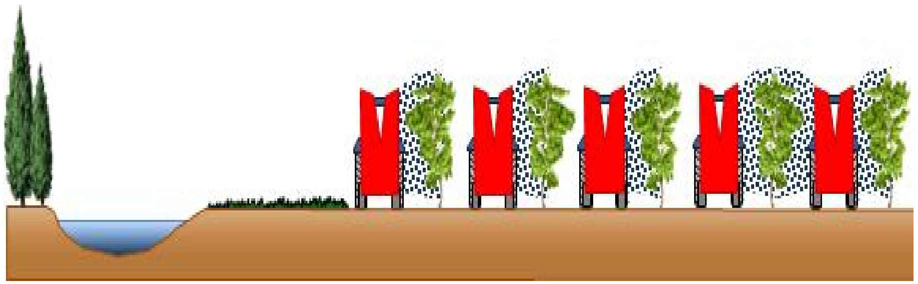
Test bench

Measurement of vertical distribution of spray liquid

Measurement of vertical air profil of the sprayer

Spray scenarios

In case of sudden changes of weather conditions different spray scenarios are recommended to be considered when spraying along sensitive areas



- if wind blows towards a sensitive area, spray border rows from outside in
- modify air support to balance the drift risk

Border rows: one sided spray from outside in

Spray scenarios can be used if spraying cannot be postponed or sudden change of wind direction occurs

Spray from the outside in

Indirect spray drift reduction measures

- Buffer zones
- Untreated zones
- Hedge rows catching the spray
- Hail nets

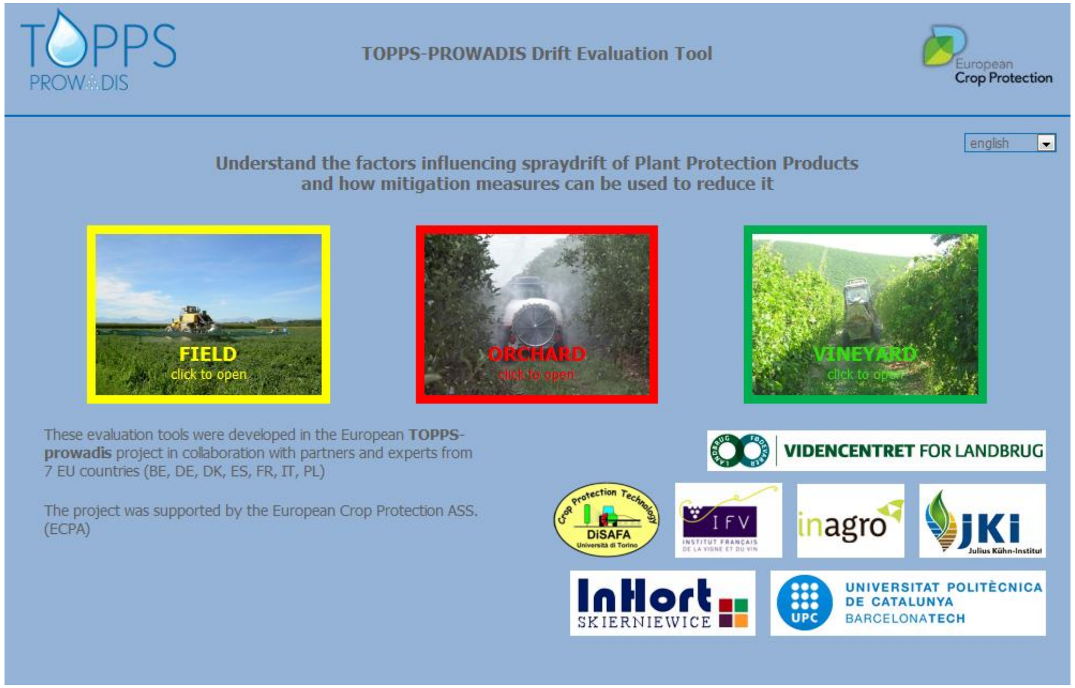
Different regulations in EU !

Some countries link buffer zones with drift reducing techniques

Future requirements: ?
label information on distance requirements concerning drift depend on drift classification of spray equipment

Understand more about drift risks and drift reduction

www.TOPPS-drift.org



Field crops / Orchards / Vine – 8 languages

Education and awareness

THE PRESENT SITUATION IN EUROPE CONCERNING BUFFER ZONES

IN THE COUNTRIES WHERE BUFFER ZONES ARE ESTABLISHED

- **DIFFERENT REFERENCE SPRAY DRIFT CURVES** ARE USED IN THE DIFFERENT COUNTRIES AS BASIS TO DEFINE BUFFER ZONES

- **WIDTH AND TYPE OF BUFFER ZONES** (NO CROP OR NO SPRAY ZONE) **ARE DEFINED ACCORDING TO SPECIFIC CRITERIA IN EACH COUNTRY**

- WIDTH OF BUFFER ZONES CAN BE WIDENED DEPENDING ON **PPP TOXICITY**

SUMMARY OF THE EU SITUATION

LACK OF AWARENESS ON THE NECESSITY FOR DRIFT MITIGATION

NOT SUFFICIENT KNOWELEDGE AND HARMONISATION ABOUT HOW THE PPP DRIFT RISK ASSESSMENT IS EVALUATED

LIMITED DIFFUSION OF DRIFT REDUCING TECHNIQUES INCLUDING SPRAYER ADJUSTMENT

BUFFER ZONE DEFINITION


Conclusion
... We have means for the cloud to disappear

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Summary: Key parameters to manage the spray drift risk in arable applications

Direct measures

- Reduce fine droplets (use spray drift reduction techniques)
- Spray with the correct boom height
- Spraying speed < 8 km /h along sensitive areas
- Plan application carefully, consider weather forecast, be especially aware when spraying along sensitive areas.

Indirect measures

- Hedgerows catch spray drift
- Consider buffer strips / untreated zones

Summary: Key parameters to manage the spray drift risk in orchard / vine applications

Direct measures

- Reduce fine droplets
- Optimize sprayer adjustment
  - air volume, speed, direction
  - liquid volume
- Select drift reducing sprayer
- Select low risk spray scenario
- Careful planning and execution of applications along sensitive areas with care

Indirect measures

- Hedgerows catch spray drift
- Hailnets reduce spray drift by about 50%
- Consider buffer strips / untreated zones

...we cannot avoid drift completely but we can largely reduce it

Acknowledgement to the TOPPS – prowadis project partners

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Inst. francaise du vigne et du vin, Grau du Roi , FR
Julius Kühn Inst. Braunschweig, DE
Bavarian State Res Inst. Freising, DE
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